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16. ABSTRACT

The catalog was developed to aid in defining the environmental impacts of U.S. industrial activity. Entries for each industry are in consistent format and form separate chapters of the catalog. The pesticides industry produces organic chemicals used: to control agricultural pests, to disinfect and condition soil, and as plant hormones. The inorganic chemicals, petroleum products, and creosote used as pesticides are specifically excluded from this chapter. The industry is discussed in 12 segments: simple and aromatic chlorinated hydrocarbons; diene-based; organophosphates; carbamates and thiocarbamates; triazines; anilides; ureas and uracils; nitrated hydrocarbons; other nitrogenous; organoarsenicals and organometallics; microbial or natural derivatives; and others. Thirteen chemical trees, 17 process flow sheets, and 37 process descriptions characterize the industry. For each process description, available data is presented on input materials, operating parameters, utility requirements, and waste streams. Related information, provided as appendices, includes company, product, and raw material data.

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INDUSTRIAL PROCESS PROFILES FOR ENVIRONMENTAL USE:
CHAPTER 8. PESTICIDES INDUSTRY

by

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PESTICIDES INDUSTRY

INDUSTRY DESCRIPTION

This industry produces the organic chemicals known as pesticides, which are used to control agricultural pests such as insects, fungus, plants and rodents, to disinfect and condition soil, and as plant hormones. This industry includes only the bulk producers and does not include other producers of preparations made from the chemicals. The inorganic chemicals, petroleum products and creosote used as pesticides are specifically excluded from this study. Such materials represent a minor use of the product chemical or are products or by-products of processes addressed in other industries.

Many products of this industry are produced by single producers. A narrow product line is either the reflection of the success of a particular line of research and the consequent proprietary position developed by the producer or an indication of similar processes utilizing the same production equipment. The rapid growth of herbicides and insecticides has been tempered by the increasing attention to long-term residual environmental effects. On the other hand, the growing worldwide need for food will continue to generate the pressure for fast-acting, selective and specific pesticides.

Over 550 pesticides have been identified, with about 200 pesticides in current production and use. Many different processes and input materials are used for these various pesticides. As a result, to present a clearer picture of the process relationships in the pesticide industry, the pesticides have been separated into 12 industrial segments with similar chemical structures and reactions. The industry segments are:

a. Simple and aromatic chlorinated hydrocarbons;
b. Diene-based;
c. Organophosphates;
d. Carbamates and thiocarbamates;
e. Triazines;
f. Anilides;

g. Ureas and uracils;
h. Nitrated hydrocarbons;
i. Other nitrogenous;
j. Organoarsenicals and organometallics;
k. Microbial or natural derivatives; and
l. Others.

These segments are described in more detail in a later section of this report. The section on pesticide industry segments includes a description of each pesticide group with typical uses, chemical structures and reactions and input materials. Representative flow sheets are included to indicate the interrelationship and similarities of the pesticide processes in each group.

The production volume for the pesticides industry has been reported at 1,258 million pounds in 1972 by the U.S. Tariff Commission. By-products from other industries (e.g., creosote) accounted for over 1 billion additional pounds. For proprietary reasons, detailed production information on pesticides with only one or two producers is not reported by the Tariff Commission. Also, disparities have been noted between reported production volumes and sales. From industrial contacts and the Tariff Commission information, Dr. Edward W. Lawless at the Midwest Research Institute has conducted an in-house review of the pesticide production. This MRI estimate of production for 1972 is presented in Appendix E.

Major pesticide production plants with capacities over 5 million pounds are located in 25 states. Many plants are found near the coasts in close proximity to refineries for supply of petroleum and chlor-alkali feedstocks. The size of the pesticide plants varies from less than 50,000 lb/year up to 200 million pounds per year.

According to information reported by Stanford Research Institute (SRI), the projected average growth through 1980 for pesticide production is 6 to 8%/year, which is slightly greater than expected growth in consumption. The difference will be exported to meet the projected 10%/year average growth in pesticide demand worldwide. The trend will be to develop highly selective pesticide formulations from commercially available chemicals. The prohibitive cost of determining the environmental impact of any new pesticide is likely to deter development and introduction of new chemicals as broad-based pesticides. The replacement of chemical insecticides by hormones and pheromones will be gradual. Much depends on future development of effective methods of application and on farmer education.

Information on the energy requirements for the pesticide industry is not generally available since many products are proprietary. The feedstock raw materials such as chlorine and sodium hydroxide may require large amounts of energy if electrolysis of brine solution is used. However, most of these feedstocks are actually products of the chlor-alkali, petroleum and chemical industries. The final pesticide reactions themselves require relatively low amounts of energy for heating and maintaining reaction temperatures, for some reflux and stripping operations and for pumping of fluids.

Raw Materials

A list of the raw materials required to produce each pesticide is included in Appendix A. This list is divided into the industrial segments. The raw materials include many petroleum-based hydrocarbon chemicals from the petroleum and chemical industry and some chlorine and sodium hydroxide from salt electrolysis or from the chlor-alkali industry. Large amounts of sulfuric and nitric acids are also used from the inorganic chemical industry. The gases including chlorine, phosgene and ammonia used in the production of some pesticides can be extremely toxic if released to the atmosphere. The heavy metal, arsenic, cyanide, and phosphate raw materials can also be a health hazard in water and air. The bases and acids are potentially corrosive and can present a health hazard.

Products

Over 200 pesticides are in current production and use in the United States. These pesticides are used as insecticides, herbicides, fungicides, fumigants, rodenticides, and for other purposes. Some of the pesticide products are also used as input materials for other pesticide processes.

Products of this industry which have been identified by the U.S. Tariff Commission are listed in Appendix B. These products are classified in SIC 28694. Company listings for these products and other pesticides have been compiled by the Stanford Research Institute from their Directory of Chemical Producers - USA. The SRI compilation is included as Appendix C. Some pesticides which are not included by the U.S. Tariff Commission are listed in Appendix D.

Companies

Over 25 companies are major producers of pesticides with production capacities above 5 million pounds. The largest plants for some major producers are listed in Table 1. Most of the producers of bulk insecticides

Table 1. SELECTED PESTICIDE PLANT LOCATIONS AND CAPACITIES IN 1972

Company	Pesticide	Plant location	Estimated plant capacity (million pounds)
Ciba-Geigy Corporation	Atrazine	McIntosh, Alabama	200
	Diazinon	St. Gabriel, Louisiana	15
Tennco Chemicals, Inc.	Toxaphene	Fords, New Jersey	125
Monsanto Chemicals	Alachlor	Muscatine, Iowa	30
	Maneb (dithiocarbamates)		15-20
	Pentachlorophenol	Sauget, Illinois	26
	Methyl parathion and parathion	Anniston, Alabama	50
Dow Chemical Company	2,4-D	Midland, Michigan	45-50
	Pentachlorophenol		18
	Dichlorobenzene		16
	Methyl bromide		15
Hercules, Inc.	Toxaphene	Brunswick, Georgia	50-75
Union Carbide Corporation	Carbaryl	Institute, West Virginia	65
E. I. du Pont de Nemours and Company	Uracils (Bromacil)	LaPorte, Texas	20
	Ureas (Diuron)		30

Table 1 (Concluded)

Company	Pesticide	Plant location	Estimated plant capacity (million pounds)
Eli Lilly and Company	Trifluralin	Lafayette, Indiana	35
Velsicol	Chlordane	Marshall, Illinois	30
	Organophosphates	Bayport, Texas	10
American Cyanamid	Malathion	Warners, New Jersey	35
Stauffer Chemical Company	Parathion and methyl parathion	Mount Pleasant, Tennessee	30
Ansul Company	MSMA	Marinette, Wisconsin	25
Diamond Shamrock Chemical Company	MSMA	Green Bayou, Texas	20
Calhio Chemical	Captan	Perry, Ohio	25
Rohm and Haas Company	Dithiocarbamates	Philadelphia, Pennsylvania	20-25
Shell Chemical Company	Aldrin	Denver, Colorado	20

are chemical companies with a few petroleum and farm chemical companies. However, the pesticide plants or facilities are usually separate from other chemical processes, and most equipment is dedicated to specific or related pesticide products.

The plants are located throughout the United States in about 25 states. Many pesticide producers are located near refineries and seacoasts to obtain petroleum and chlor-alkali feedstocks.

Environmental Impact

The pesticide industry produces many products which are toxic to humans and many more which are toxic or harmful to animals, fowl, fish, beneficial insects, and plants. These effects can be minimized by use of the least harmful, effective pesticide mixture with control of pesticide distribution, proper handling procedures and application. Even with these precautions, poisonous and carcinogenic pesticide residues are found in runoff water from land used for agricultural purposes. Some of these pesticides and pesticide residues have also been identified in the waste streams coming from pesticide production plants. The pesticide residues in plant waste streams and in agricultural runoff waters are thought by some authorities to constitute a serious public health hazard.

It should be mentioned that there is the possibility that the chlorinated hydrocarbons found in drinking water are formed during chlorination water treatment. However, with the presently available information, it would appear that the organic substances occurring in drinking water are for the large part of industrial origin. Although data on the composition of liquid waste streams from pesticide manufacturing processes are not available in the open literature, evidence exists that various organic materials are present in liquid wastes. Some organic chemicals found in pesticide plant effluents in an ongoing EPA monitoring study on carcinogens in water supplies are listed in Table 2.

Some of the feedstock chemicals and intermediate chemicals used in pesticide production also have hazardous toxic or corrosive properties. The gases including chlorine, phosgene and ammonia represent potential toxic hazards. Heavy metals, arsenic, cyanide, phosphate and partially chlorinated hydrocarbons also represent potential toxic hazards. In addition, the acids and bases used represent potential hazards to health and safety.

Table 2. ORGANIC CHEMICALS FOUND IN PESTICIDE PLANT EFFLUENTS[a]

Acenaphthene
Aldrin
Chlordane
Chlordene
m-Cresol
p-Cymene
Dieldrin
Dimethyl naphthalene isomer
Diphenyl ether
Endrin
Ethyl naphthalene ether
Tetramethylbenzene isomer
Trichlorocyclopentene isomer
Pentachlorocyclopentadiene isomers
Pentachloronorbonadiene isomer
Pentachloronorbornene isomer
Pentachloronorbornadiene epoxide isomer
Octachlorocyclopentene
Methyl naphthalene isomers
Naphthalene
Hydroxybiphenyl isomer
Isodrin
Jasmone
Heptachlor
Heptachloronorbornene isomers
Hexachlor epoxide
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloronorbonadiene isomers
Hexadieneal

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[a] From Ref. 8 in the bibliography.

The pesticide industry is aware of the toxic nature of some of its products and has taken steps to protect the industry workers and to control leakage or venting of toxic materials. Since many pesticide processes are proprietary, very little information is available on the potential toxic ingredients included in the air, water and solid wastes from these processes. Accurate information on production amounts and raw materials is even difficult to obtain for many pesticides. This lack of information prevents a full evaluation of the potential health effects from pesticide manufacturing wastes and of the environmental control methods in use by the pesticide industry.

The characterization of waste streams and of treatment or disposal methods in the process descriptions may appear to be overly simplistic. This appearance is a direct result of the lack of meaningful process data characteristic of this industry. In most cases the waste streams can be expected to contain unreacted raw materials, reaction byproducts or pesticide products, but difinitive information has never been published. An indication in the process description that the waste material is "treated" and/or "discharged", unaccompanied by more specific information, reflects the almost total lack of treatment data.

Available information indicates that the equipment used to produce pesticides is usually isolated from other company activities and is dedicated to one pesticide or similar pesticides. The gaseous emissions are often controlled by condensation recovery, scrubbing and flares. Liquid effluents from the processes and from the gas scrubbing systems represent the biggest pollution source. These liquid effluents may undergo many separation treatments including stripping, decanting, filtration, settling, and adsorption. Often, the most toxic waste streams have been injected in deep wells, dumped at sea or dewatered and buried in landfill sites.

A newer technique has been the incineration at sea on a special incinerator ship (by Shell Chemical under EPA supervision). Many pesticide residues, cancelled pesticides and waste products may also be incinerated successfully. Recently a pilot level study was conducted to determine incinerator operating condition necessary for safe disposal of pesticides. Nine pesticides in 15 liquid and solid formulation were investigated. The pesticide studied were DDT, aldrin, picloram, malathion, toxaphene, atrazine, captan, zineb and mirex. The formulated pesticide was injected into the primary combustion chamber of the incinerator. Destruction efficiencies of greater than 99.99 per cent were achieved for all pesticides tested except mirex over a range of combustion chamber temperature/retention time combinations.

Bibliography

(1) Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972. NTIS Publication.

(2) von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

(3) Lawless, E. W., T. L. Ferguson, and A. F. Meiners, Guidelines for Disposal of Small Quantities of Unused Pesticides, Midwest Research Institute for U.S. EPA, Contract No. 68-01-0098, NERC-Cincinnati, 31 August 1974.

(4) Sittig, M., Agricultural Chemicals Manufacture, Noyes Data Corporation, Chemical Process Review No. 52 (1971).

(5) Sittig, M., Pesticide Production Processes 1967, Noyes Development Corporation, Park Ridge, New Jersey (1967).

(6) Ferguson, T. L., F. J. Bergman, G. R. Cooper, R. T. Li, and F. I. Honea, Pilot Scale Incineration of Pesticides, Vol. I, Midwest Research Institute for U.S. EPA, Contract No. 68-03-0286, NERC-Cincinnati, May 1975.

(7) Ferguson, T. L., F. J. Bergman, G. R. Cooper, R. T. Li, and F. I. Honea, Determination of Incinerator Operating Conditions Necessary for Safe Disposal of Pesticides, Midwest Research Institute for U.S. EPA, Contract No. 68-03-0286, EPA-600/2-75-041, NERC, Cincinnati, December 1975.

(8) Martin, H., Pesticide Manual, British Crop Protection Council, Second Edition (1972).

(9) Suspect Carcinogens in Water Supplies, Interim Report, U.S. EPA, Office of Research and Development, April 1975.

(10) Ottinger, R. S., et al., Recommended Methods of Reduction, Neutralization, Recovery or Disposal of Hazardous Waste, Vol. 14, Summary of Waste Origins, Forms, and Quantities, Contract No. 68-03-0089, EPA 670/2-73-053-N, Redondo Beach, Ca., TRW Systems Group, 1973.

(11) Battelle Memorial Inst., Pacific Northwest Labs., Program for the Management of Hazardous Wastes, Final Report, 2 Vols., Contract No. 68-01-0762, PB-233-630, PB-233-631, Richland, Washington, 1973.

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INDUSTRY ANALYSIS

The pesticide industry has produced over 550 diffferent pesticides, and about 200 of these pesticides are in current production. Because of the variety of chemical compounds in production as pesticides, many processes are used. For many pesticides with similar chemical structure, the production processes are similar. For other pesticides derived from a common raw material, the processes are also similar. Based on these similar compounds or those with a common input raw material, the pesticide industry has been divided into 12 industrial segments.

Data for the industry analysis are presented in 12 sections, one for each segment of the industry. The order of presentation is:

1. Simple and aromatic chlorinated pesticides;
2. Diene-based chlorinated pesticides;
3. Organophosphate pesticides;
4. Carbamate pesticides;
5. Triazine pesticides;
6. Anilide pesticides;
7. Urea and uracil pesticides;
8. Nitrated hydrocarbon pesticides;
9. Other nitrogenous pesticides;
10. Organoarsenic and organometallic pesticides;
11. Microbial and natural-occurring pesticides; and
12. Other pesticides.

Each of the above 12 segments is further broken into component processes.

The chemical reaction trees and process flow sheets for individual industry segments are shown in Figures 1 through 31, with process interrelationships schematically presented on the flow sheets. Each chemical reaction tree and process flow sheet immediately follows its respective industry segment description. Processes within a particular segment are described sequentially in the section immediately following the figure on which they are shown.

Many of the production operations in the industry are proprietary, and descriptive process data are either quite limited or not available. Because of this lack of detailed information chemical trees and process flow sheets are somewhat generalized. Separate process descriptions are included to characterize those processes for which even limited data have been found. The process descriptions presented in this study are numbered consecutively and are represented by identically numbered rectangles shown on the flow sheets. Processes for which no information was found are represented by unnumbered rectangles on the flow sheets. In addition, such processes are listed at the end of each segment description.

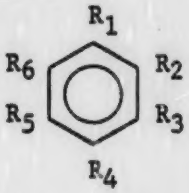
Within each process description available data have been presented on operating variables and waste streams associated with that process. Process rectangles on the flow sheets are flagged to indicate the presence of gaseous, liquid and/or solid waste streams. For most pesticide processes, little or no information is available on potential pollution problems, emissions, effluents, solid wastes, applied control technology and energy usage. For some processes, no information is available beyond potential input materials or example chemical reactions cited in patent applications.

Some pesticides can be produced by as many as eight different processes, none specifically identified with a particular producer or plant. For some of the more popular pesticides, such as atrazine, information originally supplied by the producer to MRI for other pesticide studies has been incorporated herein. For other pesticides, much more data is needed from the producers in order to make a proper evaluation of the pollution potential for their respective processes and for the industry as a whole.

Simple and Aromatic Chlorinated Hydrocarbon Pesticides

A large family of about 90 pesticides is classified as simple and aromatic chlorinated pesticides. These pesticides include acylic and cyclic hydrocarbons with at least one chlorine atom.

The simple and aromatic chlorinated hydrocarbon pesticides can be separated into three groups: (a) simple chlorinated hydrocarbons; (b) DDT-family of chlorinated hydrocarbons; and (c) aromatic-chlorinated hydrocarbons. The "phenoxie" pesticides have phenol as a base and are included as aromatic chlorinated hydrocarbons. The simple chlorinated hydrocarbon pesticides have no common configuration. DDT, DDD, methoxychlor and hexachlorophene include two aromatic rings in a "di" configuration. The general structure of the aromatic-chlorinated hydrocarbons is:



where at least one R group is chlorine as summarized in the following tabulation.

Aromatic pesticide	R_1	R_2	R_3	R_4	R_5	R_6
"Phenoxies"						
2,4-D	$-OCH_2COOH$	-Cl	-H	-Cl	-H	-H
2,4-DB	$-OCH_2CH_2COOH$	-Cl	-H	-Cl	-H	-H
MCPA	$-OCH_2COOH$	$-CH_3$	-H	-Cl	-H	-H
MCPB	$-CH_2CH_2COOH$	$-CH_3$	-H	-Cl	-H	-H
2,4,5-T	$-OCH_2COOH$	-Cl	-H	-Cl	-Cl	-H
Silvex	$-OCH(CH_3)COOH$	-Cl	-H	-Cl	-Cl	-H
Bromoxynil	-CN	-H	-Br	-OH	-Br	-H
PCP	-OH	-Cl	-Cl	-Cl	-Cl	-Cl
2,4,5-Trichlorophenol	-OH	-Cl	-H	-Cl	-Cl	-H
Others						
PCNP	$-NO_2$	-Cl	-Cl	-Cl	-Cl	-Cl
2,3,6-TBA	-COOH	-Cl	-H	-Cl	-H	-Cl
Chloramben	-COOH	-H	-Cl	-H	$-NH_2$	-Cl
Dichlorobenzene	-Cl	-H	-H	-Cl	-H	-H
Hexachlorobenzene	-Cl	-Cl	-Cl	-Cl	-Cl	-Cl
Dicamba	-COOH	$-OCH_3$	-Cl	-H	-H	-Cl

The "phenoxies" are more commonly available in a salt form compared to the acid form. 2,4-D is also sold in an ester form. Although bromoxynil is a brominated aromatic hydrocarbon, it is still often classified as a "phenoxie" and is included here.

The annual production in 1972 of the chlorinated hydrocarbon pesticides included in this industry segment is estimated at over 380 million pounds (about 30% of all pesticides). Toxaphene, which is the most popular pesticide, accounts for 95 million pounds. DDT still accounts for 40 million pounds as an insecticide, and methoxychlor accounts for 3 million. The "phenoxies" are used as herbicides with 2,4-D amine salts at 22.7 million pounds and acids and esters at 30 million pounds. Other "phenoxies" include 2,4,5-T at 7 million pounds, Silvex at 3 million pounds, and MCPA at 2 million pounds.

Herbicides include chloramben at 20 million pounds and TCA at 11.3 million pounds. Fungicides include PCP at 49.7 million pounds and 2,4,5-trichlorophenol at 18 million pounds. In addition, soil fumigants include dichloropropene at 20 million pounds.

The use of the DDT family and toxaphene pesticides is expected to decrease as substitutes are found.

Many of the chemical reactions for chlorinated hydrocarbon pesticides are indicated in Figure 1. Figure 2 is the flow sheet for the simple chlorinated hydrocarbon pesticides. The flow sheets for the DDT family and other chlorinated aromatic hydrocarbons are presented in Figures 3 and 4.

Data on several of the individual processes in this industry segment were not available in the literature and detailed process descriptions could not be prepared. These processes are:

Methoxychlor Process
DDD Process
Trichlorophenol Process
Dichlorophenol Process
MCPA Process
MCPB Process
Hexachlorophene Process
2,4,5-T Process

Silvex Process
Dicamba Process
Hexachlorobenzene Process
Benzene Hexachloride (BHC) Process
Dachtal Process
TBA Process
Chloramben Process

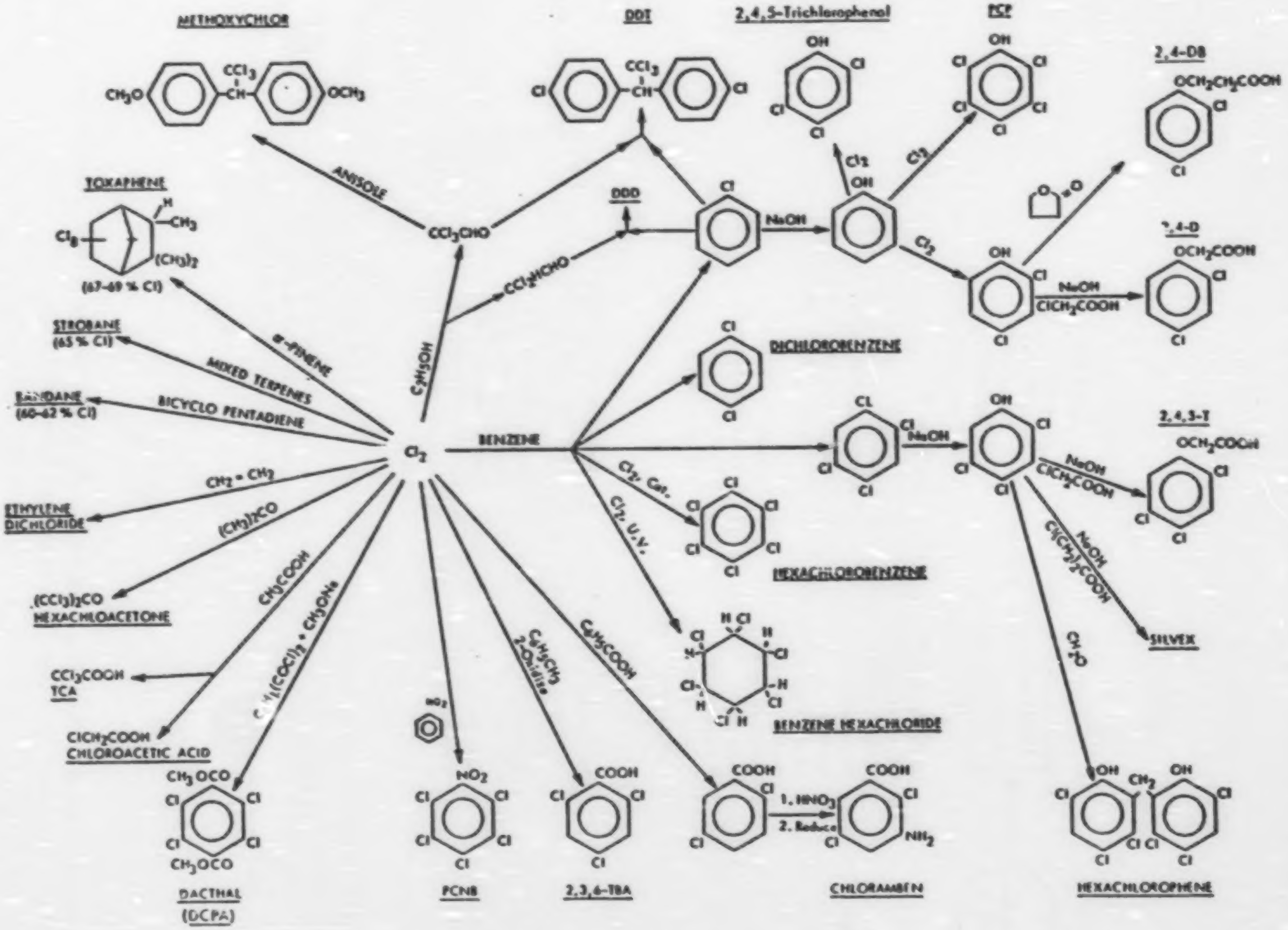
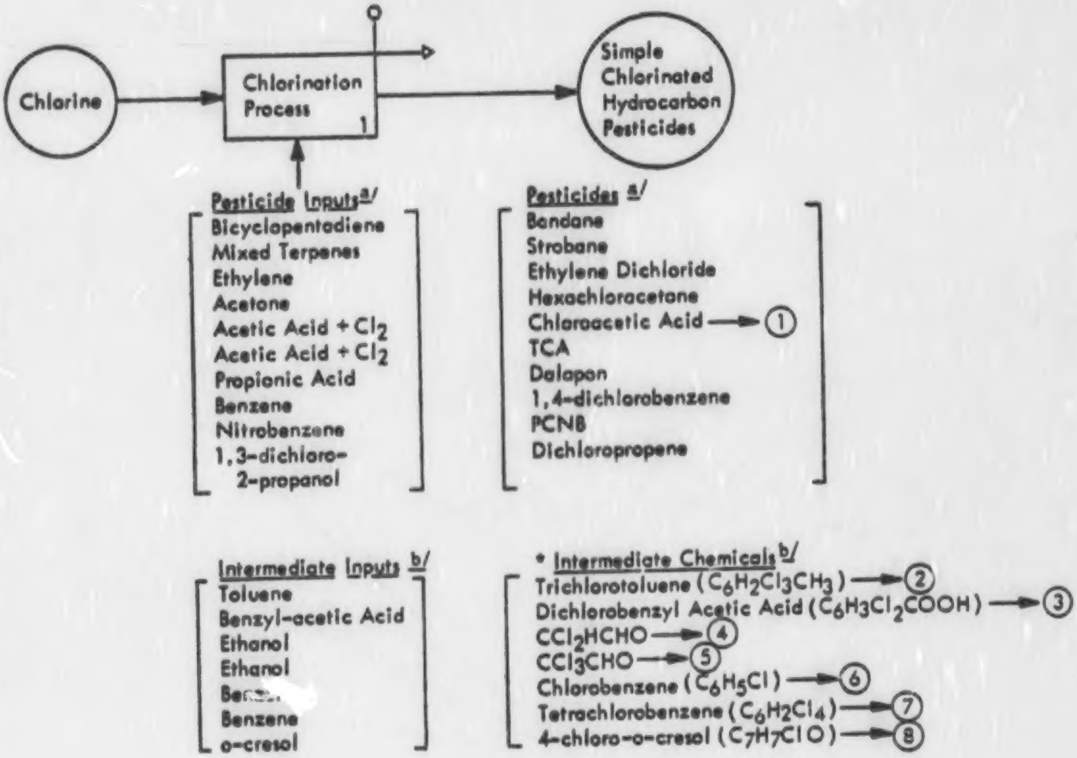

METHOXYCHLOR
DDT
2,4,5-Trichlorophenol
PCP
2,4-DB
2,4-D
2,4,5-T
SILVEX
HEXACHLOROPHENE
CHLORAMBEN
2,3,6-TBA
PCNB
DACTHAL
(DCPA)
CHLOROACETIC ACID
TCA
HEXACHLOACETONE
ETHYLENE DICHLORIDE
BANDANE (60-62 % Cl)
STROBANE (65 % Cl)
TOXAPHENE (67-69 % Cl)
DDD
DICHLOROBENZENE
HEXACHLOROBENZENE
BENZENE HEXACHLORIDE
Cl2
BENZENE
ANISOLE
CCl3CHO
C2H5OH
CCl2HCHO
α-PINENE
MIXED TERPENES
BICYCLO PENTADIENE
CH2 = CH2
(CH3)2CO
CH3COOH
CCl3COOH
ClCH2COOH
(CCl3)2CO
C6H4(COCl)2 + CH3ONa
C6H5CH3 2-Oxidize
C6H5COOH
1. HNO3 2. Reduce
Cl2, Cat.
Cl2, U.V.
NaOH
NaOH ClCH2COOH
NaOH CH(CH3)2COOH
CH2O
CH3O
OCH3
CCl3
CH
OH
Cl
NO2
COOH
NH2
OCH2CH2COOH
OCH2COOH
CH2

Figure 1. Synthesis of some chlorinated hydrocarbons and related pesticides

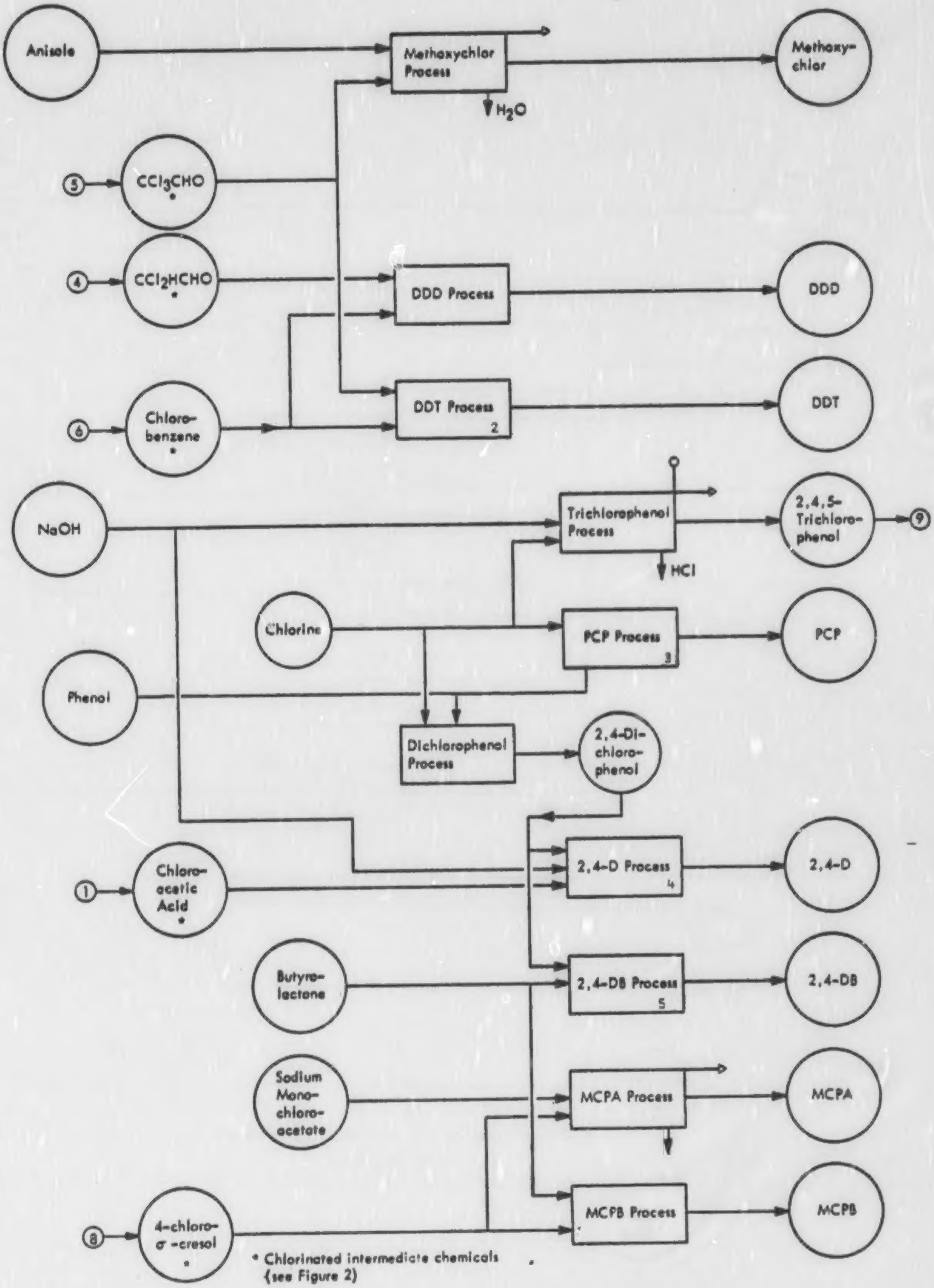

Chlorine
Chlorination Process
1
Simple Chlorinated Hydrocarbon Pesticides
Pesticide Inputs a/
Bicyclopentadiene
Mixed Terpenes
Ethylene
Acetone
Acetic Acid + Cl_2
Acetic Acid + Cl_2
Propionic Acid
Benzene
Nitrobenzene
1,3-dichloro-2-propanol
Pesticides a/
Bandane
Strobane
Ethylene Dichloride
Hexachloracetone
Chloroacetic Acid ①
TCA
Dalapon
1,4-dichlorobenzene
PCNB
Dichloropropene
Intermediate Inputs b/
Toluene
Benzyl-acetic Acid
Ethanol
Ethanol
Ben[illegible]
Benzene
o-cresol
* Intermediate Chemicals b/
Trichlorotoluene ($C_6H_2Cl_3CH_3$) ②
Dichlorobenzyl Acetic Acid ($C_6H_3Cl_2COOH$) ③
CCl_2HCHO ④
CCl_3CHO ⑤
Chlorobenzene (C_6H_5Cl) ⑥
Tetrachlorobenzene ($C_6H_2Cl_4$) ⑦
4-chloro-o-cresol (C_7H_7ClO) ⑧

---

[a] These input chemicals are required to produce the pesticides directly in line across the process

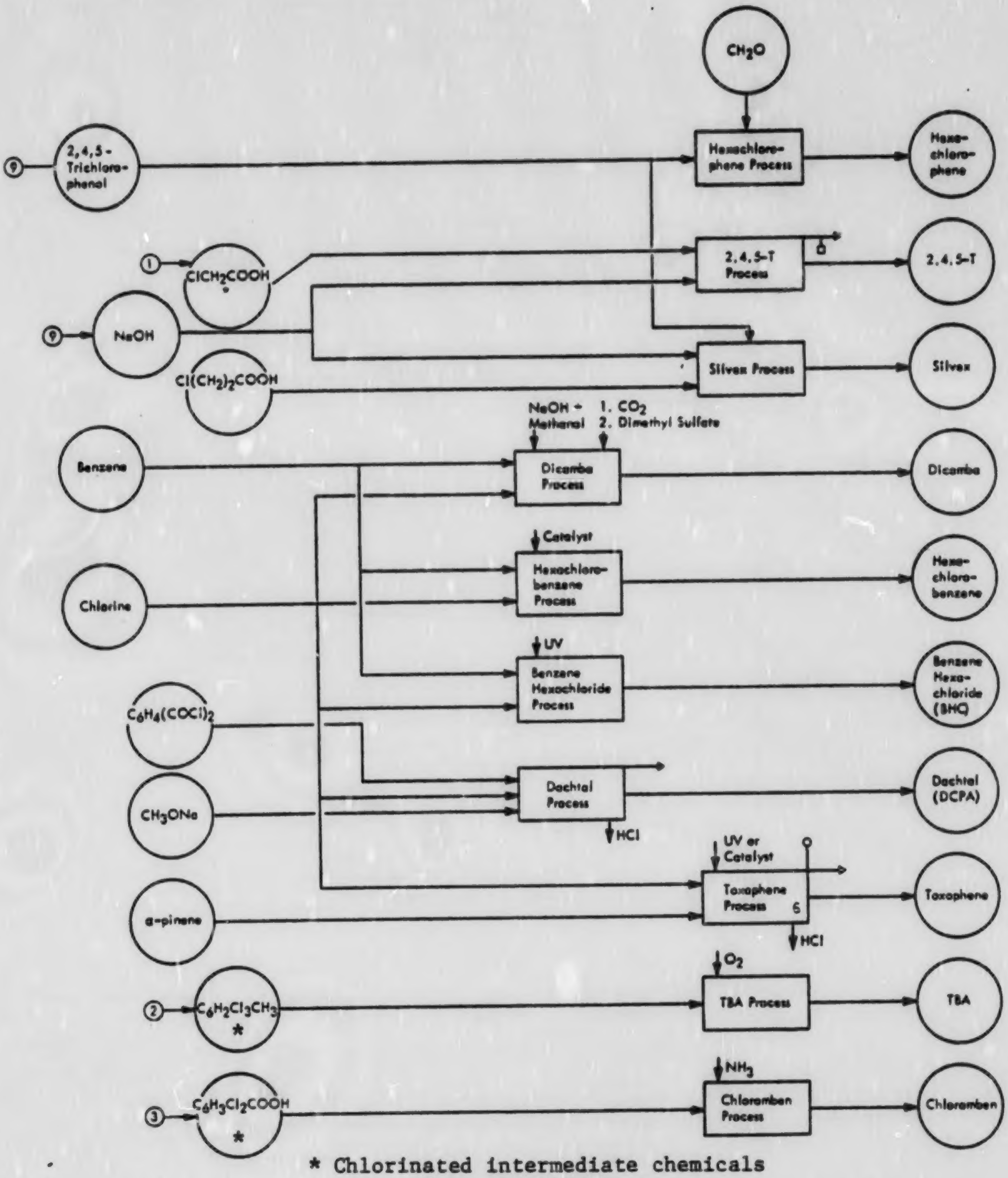
[b] These intermediate input chemicals are required to produce the inline intermediate chemicals. The intermediate chemicals are used in other pesticide processes as indicated in Figures 3 and 4.

Figure 2. Flow sheet for simple chlorinated hydrocarbon pesticides and intermediate chemicals


Anisole
Methoxychlor Process
H_2O
Methoxy-chlor
5
CCl_3CHO
4
CCl_2HCHO
DDD Process
DDD
6
Chloro-benzene
DDT Process
2
DDT
NaOH
Trichlorophenol Process
HCl
2,4,5-Trichloro-phenol
9
Chlorine
PCP Process
3
PCP
Phenol
Dichlorophenol Process
2,4-Di-chloro-phenol
1
Chloro-acetic Acid
2,4-D Process
4
2,4-D
Butyro-lactone
2,4-DB Process
5
2,4-DB
Sodium Mono-chloro-acetate
MCPA Process
MCPA
8
4-chloro-σ-cresol
MCPB Process
MCPB

* Chlorinated intermediate chemicals (see Figure 2)

Figure 3. Flow Sheet for DDT and some aromatic chlorinated hydrocarbon pesticides


CH$_2$O
9
2,4,5-Trichlorophenol
Hexachlorophene Process
Hexachlorophene
1
ClCH$_2$COOH
2,4,5-T Process
2,4,5-T
9
NaOH
Cl(CH$_2$)$_2$COOH
Silvex Process
Silvex
NaOH + Methanol
1. CO$_2$
2. Dimethyl Sulfate
Benzene
Dicamba Process
Dicamba
Catalyst
Chlorine
Hexachlorobenzene Process
Hexachlorobenzene
UV
Benzene Hexachloride Process
Benzene Hexachloride (BHC)
C$_6$H$_4$(COCl)$_2$
CH$_3$ONa
Dachtal Process
HCl
Dachtal (DCPA)
UV or Catalyst
α-pinene
Toxaphene Process
HCl
Toxaphene
O$_2$
2
C$_6$H$_2$Cl$_3$CH$_3$
*
TBA Process
TBA
NH$_3$
3
C$_6$H$_3$Cl$_2$COOH
*
Chloramben Process
Chloramben

* Chlorinated intermediate chemicals
(see Figure 2)

Figure 4. Flow sheet for aromatic chlorinated hydrocarbon pesticides

Dichlorobenzene Chlorination Process

1. Function - The dichlorobenzene chlorination process consists of three process steps; the chlorination of the benzene, product recovery, and waste treatment and recovery.

   In the chlorination step, dry benzene is charged into a lead or glass-lined chlorinator containing about 1% by weight (of the benzene charged) of iron turnings to be used as the catalyst. Chlorine is then bubbled into the charge at the rate necessary to maintain a constant temperature. This step yields waste HCl and chlorinated benzenes.

   To recover the dichlorobenzene, the chlorinated benzenes are neutralized with an aqueous solution (10%) of caustic soda and then sent to a separator. A sludge rich in dichlorobenzene settles out and is withdrawn at the bottom. The lighter materials are withdrawn and then distilled. The distillation yields benzene and water, benzene and chlorobenzene, chlorobenzene, and dichloro- and poylchlorobenzenes. The dichloro- and polychlorobenzenes and the sludge are then processed for final recovery of dichlorobenzene.

   The basic waste product is the HCl by-product of the chlorination process. This HCl is scrubbed with benzene or chlorobenzene and then is absorbed in water to give hydrochloric acid. The benzene or chlorobenzene from the scrubbing process is circulated into the chlorination step of the process.

2. Input Materials - Benzene and chlorine.

3. Operating Parameters - Chlorination temperature, 40 to 60°C.

4. Utilities - Data not available.

5. Waste Streams - At one plant, liquid plant wastes containing polychlorobenzenes go to an approved landfill.

6. EPA Source Classification Code - None exists.

7. Reference -

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

DDT Process

1. **Function** - DDT is produced by the reaction of of chloral (or chloral hydrate) and chlorobenzene in the presence of H_2SO_4. The process consists of four basic stages: the reaction, separation of DDT, processing of DDT, and waste control and recovery.

   In the two-stage reactor step, two moles of C_6H_5Cl are reacted with one mole of CCl_3CHO with H_2SO_4 as a catalyst to form DDT. In this step, excess C_6H_5Cl and the spent H_2SO_4 along with the DDT are then introduced to the DDT separator.

   In the DDT separator, the DDT is extracted from the excess C_6H_5Cl and H_2SO_4. There are two waste recovery streams from this step, one for H_2SO_4 and one for C_6H_5Cl. The product stream contains the unpurified and unprocessed DDT.

   The DDT processing step consists of several stages. First the DDT is washed with NaOH and H_2O. The waste stream from this process contains dilute caustic. The DDT then goes through a crystallizing, drying, flaking stage from which it passes to either the packaging or formulation process. At each stage through the final processing there is some recovery of C_6H_5Cl.

   The DDT process contains three waste recovery steps. One step removes the C_6H_5Cl from the separating and processing streams and recycles it to the reaction step. The second step first removes the acid from the separator stream. This acid is cycled through an acid recovery plant from which the recovered acid is recycled to the initial reaction step. The waste acid from the recovery plant is then combined with the dilute caustic in a neutralizer. The final step is the recovery of waste from clean-up operations.

2. **Input Materials** - Chloral and chlorobenzene.

3. **Operating Parameters** - Data not available.

4. **Utilities** - Data not available.

5. **Waste Streams** - Wastes resulting from the process include spent hydrochloric and sulfuric acids, monochloral benzene, sodium monochloral benzene sulfonate, chloral, NaOH caustic washwaters, chlorobenzene, sulphonic acid, and some product. The waste streams may

contain DDT in the 1-5 ppm range with DDE and other related compounds present in amounts up to four times the DDT level. The pH of the waste is low and the salt content is high. At one plant, the primary waste stream containing waste acid and dilute caustic is neutralized and sent to a Class I dump.

6. *EPA Source Classification Code* - None exists

7. *References* -

Atkins, Patrick R., *The Pesticide Manufacturing Industry-Current Waste Treatment and Disposal Practices*, for U.S. EPA, Office of Research and Monitoring, Project No. 12020 FYE, January 1972.

Lawless, E. W., R. von Rümker, and T. L. Ferguson, *The Pollution Potential in Pesticide Manufacture*, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972. NTIS Publication.

Pentachlorophenol (PCP) Process

1. Function - Pentachlorophenol is produced by the simple chlorination of phenol in the presence of anhydrous aluminum chloride. The process steps consist of a two-stage reaction and HCl recovery.

   In the primary reactor, an excess of chlorine is added to phenol to give the product pentachlorophenol. The wastes from this process are cycled to the secondary reactor where more phenol is added. The products of the second reactor are partially chlorinated phenols and HCl. The phenols are recycled to the primary reactor, and the HCl is recovered and cycled through a recovery process.

2. Input Materials - Phenol and chlorine.

3. Operating Parameters - Initial temperature of phenol, 65 to 130°C; preferably 105°C.
   - Atmospheric pressure.
   - Reaction time varies from 5 to 15 hr.

4. Utilities - Data not available.

5. Waste Streams - At one plant, wastewater containing lower chlorinated phenols is sent to a treatment facility.

6. EPA Source Classification Code - None exists.

7. References -

Sittig, M., Pesticide Production Processes 1967, Noyes Development Corporation, Park Ridge, New Jersey (1967).

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

2,4-D Process
(2,4-Dichlorophenoxyacetic Acid)

1. Function - 2,4-D is produced and recovered in a three-step process with each step involving a distinct chemical reaction. First, chloroacetic acid is combined with sodium hydroxide to obtain $ClCH_2COONa$. This is combined with neutralized 2,4-dichlorophenol in a condensation reactor to produce 2,4-D sodium salt. The salt is then reacted with HCl to form 2,4-D and NaCl. The 2,4-D is then recovered and cycled to a drying system. The NaCl is also recovered. At this same stage of the process, the excess dichlorophenol is recovered and returned to the condensation reactor.

   There are three waste streams from the 2,4-D recovery step. At one of the plants manufacturing 2,4-D, dusts are collected and recycled. Liquid wastes are chemically treated, passed through a special trickling filter, and then to a biological waste treatment plant. Solid wastes, still bottoms, etc., are incinerated; the combustion gases are scrubbed; the water is chemically treated, and then sent to a bio-waste plant.

2. Input Materials - 2,4-Dichlorophenol, chloroacetic acid, and NaOH.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - Waste streams from chlorinated hydrocarbon herbicides such as 2,4-D include large amounts of sodium chloride, hydrochloric acid, some caustic, and organics including solvents, phenols, chlorophenols and chlorophenoxy acids. These wastes arise from acidification, washing steps, phase separation steps, incomplete yields and chlorination of the phenolic compounds. A typical waste stream can be characterized by:

COD	8,300 mg/l
BOD_5	6,300
Total Solids	104,000
Suspended Solids	2,500
pH	0.5

Chlorides	52,000
Chlorophenols	112
Chlorophenoxy Acids	235
Nitrogen	Low
Phosphorus	Low
Flow	30 # COD/# Product

The chlorinated herbicide wastes can vary considerably from plant to plant and even in the same plant as indicated by the data in Table 3.

6. EPA Source Classification Code - None exists.

7. References -

Atkins, Patrick R., The Pesticide Manufacturing Industry-Current Waste Treatment and Disposal Practices, for U.S. EPA, Office of Research and Monitoring, Project No. 12020 FYE, January 1972.

Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972. NTIS Publication.

Sittig, M., Pesticide Production Processes 1967, Noyes Development Corporation, Park Ridge, New Jersey (1967).

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Table 3. WASTE CHARACTERISTICS OF CHLORINATED HERBICIDE WASTES[a]

Analysis	2, 4, 5-T Acid Waste			2, 4-D Acid Waste		
	Sample #1	Sample #2	Sample #3	Sample #1	Sample #2	Sample #3
pH	7.5	7.9		8.5	9.5	
COD (mg/l)	21,700	25,700	19,600	27,500	23,600	22,700
BOD_5 (mg/k)[b]	16,800	b/	13,400	16,700	b/	13,000
Chlorides (mg/l)	96,300	69,000		144,000	72,000	
Total Solids (mg/l)		172,467			167,221	
Total Volatile Solids (mg/l)		18,150			22,100	
Suspended Solids (mg/l)		700			348	
Volatile Suspended Solids (mg/l)		242			83	
Total Kjeldahl Nitrogen (mg/l)		40			45	
Odors		Not Offensive			Not Offensive	

a/ Source: Patrick Atkins, The Pesticide Manufacturing Industry - Current Waste Treatment and Disposal Practices, for U.S. EPA, Office of Research and Monitoring, Project No. 12020 FYE, January 1972.

b/ 16,680 mg/l using 50-50 dilution of 2, 4-D and 2, 4, 5-T and acclimated seed (below toxic levels)

2,4-DB Process

1. Function - 2,4-Dichlorophenol, butyrolactone, and NaOH are combined in a two-stage reaction to form 2,4-DB. The first reaction combines the dichlorophenol and the sodium hydroxide to form alkali phenolate according to the equation:

   $$Cl_2C_6H_3OH + NaOH \longrightarrow Cl_2C_6H_3ONa + H_2O.$$

   This product is then combined with the butyrolactone to produce 2,4-DB.

   The 2,4-DB is then removed and cycled through a centrifuge process. The wastes from the reaction and the centrifuge are cycled through a recovery process to regain excess reactants. These are then recycled to the system.

2. Input Materials - 2,4-Dichlorophenol, butyrolactone, and NaOH.

3. Operating Parameters - First reaction temperature: 50 to 200°C.
   - pressure: atmospheric.
   - time: 0.5 to 24.0 hr.
   - Second reaction temperature: 135 to 210°C.
   - pressure: atmospheric.
   - time: 1 to 6 hr.

4. Utilities - Data not available.

5. Waste Streams - Data not available.

6. EPA Source Classification Code - None exists.

7. Reference -

   U.S. Patent No. 3,076,025.

Toxaphene Process

1. Function - Toxaphene is produced by chlorination of α-pinene (or camphene). The α-pinene is reacted with a catalyst to form toxaphene solution. The solution is filtered and stripped to obtain the toxaphene product. The chlorinator waste HCl gas passes through a water absorber and the resulting muriatic acid is recovered or neutralized and sent to wastewater treatment. The toxaphene product then goes either to a solution or to a dust formulation step. Emissions from the dust formulation are vented to a baghouse, with the captured dust then recycled to the formulation step.

2. Input Materials - α-pinene (or camphene) and chlorine.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - At one plant, the waste streams containing HCl are treated before being discharged into a tidal creek.

6. EPA Source Classification Code - None exists.

7. References -

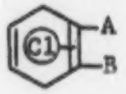
Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972. NTIS Publication.

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Diene-Based Chlorinated Pesticides

A large group of insecticides known as the diene-based group of chlorinated insecticides have been derived from hexachlorocyclopentadiene. This group includes 13 pesticides: aldrin, dieldrin, heptachlor, chlordane, isodrin, endrin, endosulfan, isobenzan (telodrin), alodan, bromodan, kepone, mirex, and pentac. Toxaphene has a similar chemical structure and is sometimes grouped together with the dienes as the aldrin-toxaphene group.

The structure of many diene pesticides is of the form:



where the Cl denotes a saturated chlorinated loop and A and B are side chains. A and B are quite often linked together to form another loop, as indicated for some diene pesticides in Figure 5, which summarizes reaction sequences for diene insecticides.

The estimated annual production of diene group pesticides in 1972 included: aldrin (14 million pounds), chlordane (20 million), heptachlor (7 million), endrin (4 million), endosulfan (2 million), dieldrin (0.5 million), mirex (0.3 million), and kepone (0.1 million).

The production trend is downwards since aldrin and dieldrin have been banned by the EPA because of high toxicity and low degradable, long-term persistence. The uses of heptachlor have also been cancelled and chlordane is being reviewed. Mirex, which received widespread use for fire ants, is also restricted by the EPA.

The process flow diagram for the diene group is presented in Figure 6. The hexachlorocyclopentadiene intermediate chemical used for all dienes is produced from dicyclopentadiene with chlorination (Process 7). Most of the diene pesticide processes include a Diels-Alder addition reaction (Process 9) for direct synthesis or for synthesis of intermediate chemicals. The diene pesticide processes utilizing these intermediate chemicals are also indicated (Processes 10 through 13).

A typical waste stream from a diolefin based chlorinated hydrocarbon pesticide manufacture will include:

COD	500 mg/l
BOD_5	50
Total Solids	1,000

Suspended Solids	100 mg/l
pH	2
Chlorides	High
Nitrates	?
Phosphates	?
Product	100-300 ppb as Endrin
Toxicity	High
Flow	0.375 gallons treated wastewater/# product

(This does not include concentrated liquids, tank "bottoms", spent catalysts, etc., which are normally landfilled.)

Data on several of the processes within this industry segment were not available in the literature. Therefore, detailed descriptions of these processes were not prepared. These processes are:

Pentac Process
Kepone Process
Heptachlor Process
Endosulfan Process
Isobenzan Process

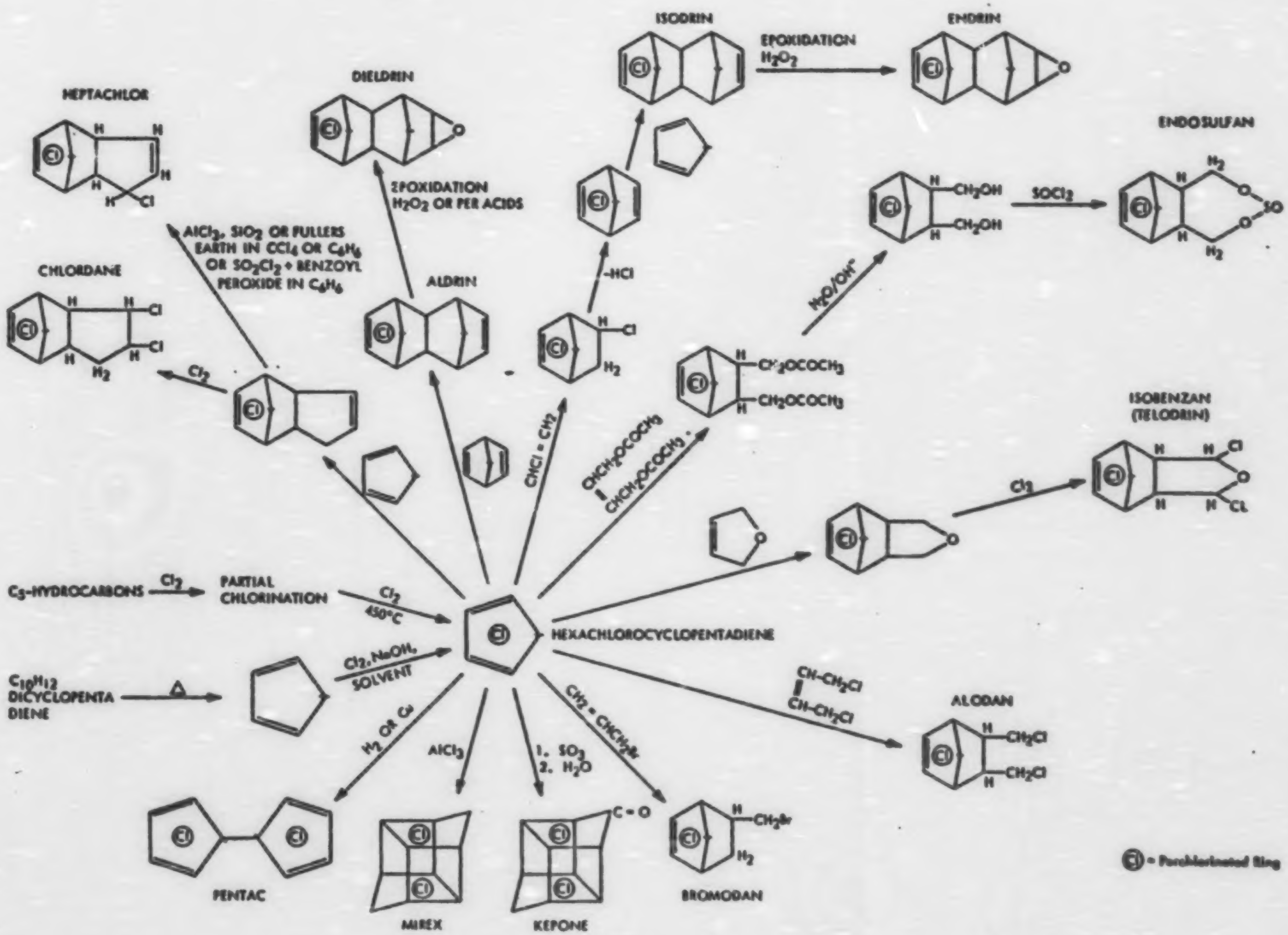
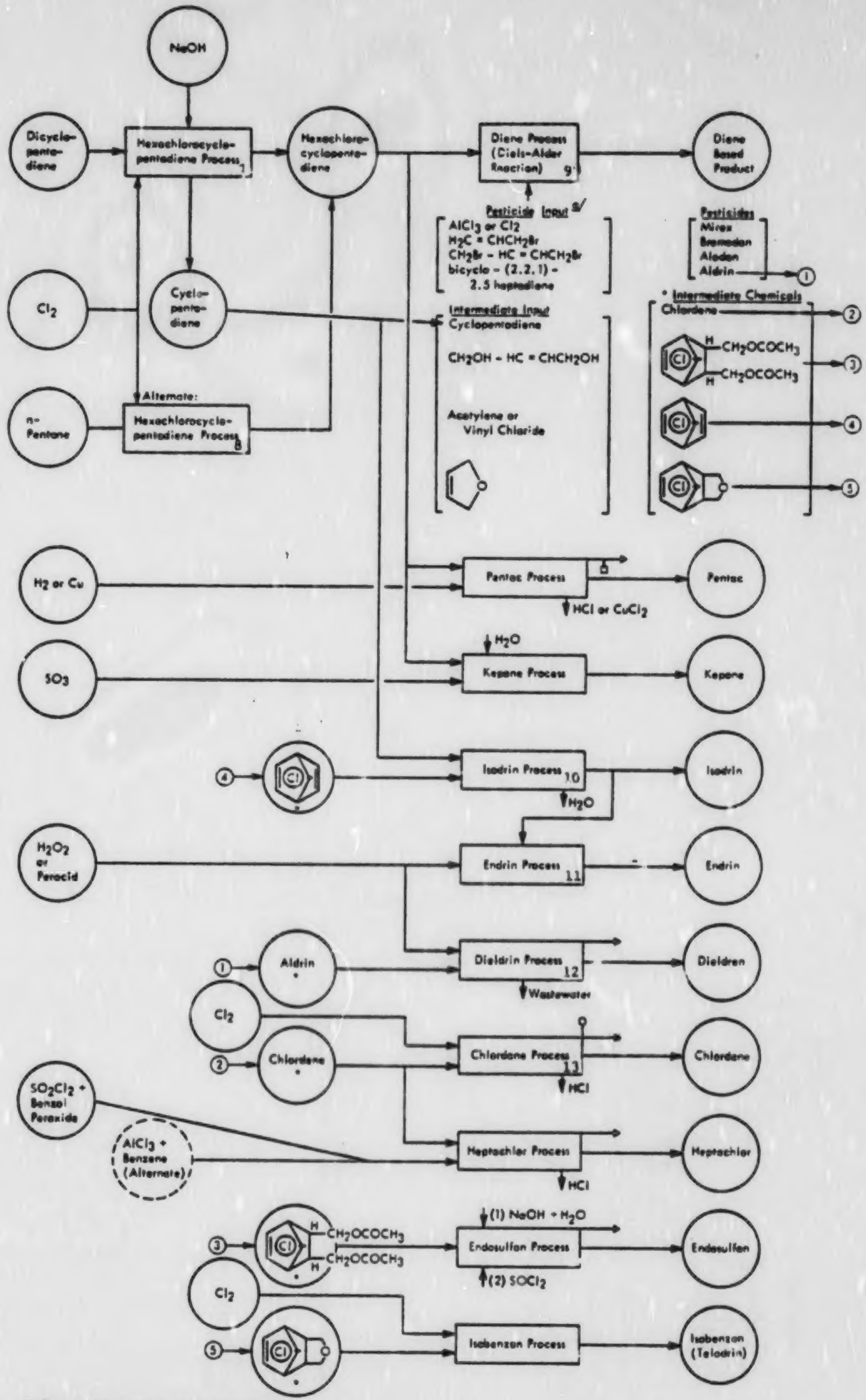

HEPTACHLOR
DIELDRIN
ISODRIN
EPOXIDATION H_2O_2
ENDRIN
ENDOSULFAN
EPOXIDATION H_2O_2 OR PER ACIDS
$AlCl_3$, SiO_2 OR FULLERS EARTH IN CCl_4 OR C_6H_6 OR SO_2Cl_2 + BENZOYL PEROXIDE IN C_6H_6
CHLORDANE
ALDRIN
-HCl
H_2O/OH^-
$SOCl_2$
Cl_2
$CHCl = CH_2$
$CHCH_2OCOCH_3$ = $CHCH_2OCOCH_3$
ISOBENZAN (TELODRIN)
Cl_2
C_5-HYDROCARBONS
PARTIAL CHLORINATION
Cl_2 450°C
HEXACHLOROCYCLOPENTADIENE
$C_{10}H_{12}$ DICYCLOPENTA DIENE
Cl_2, NaOH, SOLVENT
$CH-CH_2Cl$ = $CH-CH_2Cl$
ALODAN
H_2 OR Cu
$AlCl_3$
1. SO_3 2. H_2O
$CH_2 = CHCH_2Br$
PENTAC
MIREX
KEPONE
BROMODAN
Ⓒl = Perchlorinated Ring

Figure 5. Synthesis of the diene group of chlorinated insecticides--from hexachlorocyclopentadiene


NaOH
Dicyclo-pentadiene
Hexachlorocyclopentadiene Process 7
Hexachlorocyclopentadiene
Diene Process (Diels-Alder Reaction) 9
Diene Based Product
Pesticide Input a/
AlCl3 or Cl2
H2C = CHCH2Br
CH2Br - HC = CHCH2Br
bicyclo - (2.2.1) - 2.5 heptadiene
Pesticides
Mirex
Bromodan
Alodan
Aldrin
①
* Intermediate Chemicals
Chlordene
②
CH2OCOCH3
CH2OCOCH3
H
H
③
④
⑤
Cl
Cl2
Cyclopentadiene
Intermediate Input
Cyclopentadiene
CH2OH - HC = CHCH2OH
Acetylene or Vinyl Chloride
n-Pentane
Alternate:
Hexachlorocyclopentadiene Process 8
H2 or Cu
Pentac Process
HCl or CuCl2
Pentac
H2O
SO3
Kepone Process
Kepone
④
Isodrin Process 10
H2O
Isodrin
H2O2 or Peracid
Endrin Process 11
Endrin
①
Aldrin
Dieldrin Process 12
Wastewater
Dieldren
Cl2
②
Chlordene
Chlordane Process 13
HCl
Chlordane
SO2Cl2 + Benzol Peroxide
AlCl3 + Benzene (Alternate)
Heptachlor Process
HCl
Heptachlor
③
CH2OCOCH3
CH2OCOCH3
(1) NaOH + H2O
Endosulfan Process
(2) SOCl2
Endosulfan
Cl2
⑤
Isobenzan Process
Isobenzan (Telodrin)

* Diene intermediate chemicals from processes.

a/ Inputs and products are lined up respectively.

Figure 6. Flow sheet for diene-based pesticides processes

Hexachlorocyclopentadiene Process

1. Function - Both hexachlorocyclopentadiene and cyclopentadiene are produced in this process utilizing dicyclopentadiene. This is a two-step process involving first a separation step and then a chlorination step.

   First, the dicyclopentadiene is heated in order to cause separation. At this point, the cyclopentadiene is either recovered, or introduced to chlorine and sodium hydroxide in the chlorination step. The solvent for the chlorination is either CCl_4 or perchloroethylene. The product is then recovered as pentachlorocyclopentadiene. The only waste stream in the process is after the chlorination step and contains NaCl. This is cycled through a waste treatment system.

2. Input Materials - Chlorine, sodium hydroxide, and dicyclopentadiene.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - Water scrubber: Water + HCl.
   - Chlorination: Water + NaCl.

6. EPA Source Classification Code - None exists.

7. Reference -

   Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

Hexachlorocyclopentadiene Process (alternate)

1. Function - Hexachlorocyclopentadiene is produced by the chlorination of n-pentane in this process. The basic steps are the reaction, a heat exchange, and the product recovery.

   The chlorine and n-pentane are introduced into a burner reactor in the presence of an anhydrous H_2SO_4 catalyst. The chlorinated products then pass through a heat exchanger and into the product absorption column. The solvent in the column is either CCl_4 or perchloroethylene. After the absorption step the stream is passed to a distillation unit for recovery of the hexachlorocyclopentadiene.

2. Input Materials - Chlorine and n-pentane.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - H_2SO_4 Dryer: H_2SO_4 and H_2O.
   - Water scrubber: HCl and H_2O.

6. EPA Source Classification Code - None exists.

7. Reference -

   Sittig, M., Pesticide Production Processes 1967, Noyes Data Corporation (1967).

Diene Process, Aldrin

1. Function - Aldrin is produced by reacting hexachlorocyclopentadiene and bicyclo-(2.2.1)-2,5-heptadiene. The process includes a reaction step in which the C_5Cl_6 and the C_7H_8 are combined and a solvent stripper step in which the aldrin and excess C_7H_8 are separated. The wastes are treated and passed to an asphalt-lined evaporation basin at one plant.

2. Input Materials - Hexachlorocyclopentadiene and bicyclo-(2.2.1)-2,5-heptadiene.

3. Operating Parameters - Reaction temperature: 80 to 150°C.
   - Reaction pressure: Atmospheric.
   - Reaction time: Batch - 18 hr.
     Continuous - 4 to 8 hr.

4. Utilities - Data not available.

5. Waste Streams - Liquid waste containing aldrin to the level of solubility are sent to an asphalt-lined evaporation basin at one plant.

6. EPA Source Classification Code - None exists.

7. References -

Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

von Rümker, R., E. W Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Isodrin Process

1. Function - Isodrin is produced by a two-stage reaction using hexachlorocyclopentadiene, acetylene, and cyclopentadiene. The first stage is the Diels-Alder condensation reaction of hexachlorocyclopentadiene and acetylene as indicated in Process No. 9. The second stage is the condensation reaction of the Diels-Alder product and cyclopentadiene to form isodrin.

2. Input Materials - Hexachlorocyclopentadiene, acetylene (or vinyl chloride), and cyclopentadiene.

3. Operating Parameters - Diels-Alder condensation:
   - Temperature: 150 to 175°C.
   - Pressure: 2,000 to 4,000 psi with acetylene.
   - Reaction time: 0.5 to 3.0 hr.
   - Phase: Liquid, no solvent.
   - Equipment: Special design reactor.

   - Isodrin condensation:
   - Temperature: 50 to 90°C (exothermic).
   - Reaction time: 2 hr after gradual reactant addition.
   - Phase: Liquid, no solvent.
   - Equipment: Stirred, jacketed kettle with reflux condenser.

4. Utilities - Data not available.

5. Waste Streams - Waste streams probably contain some amounts of HCl.

6. EPA Source Classification Code - None exists.

7. Reference -

Sittig, M., Pesticide Production Processes 1967, Noyes Data Corporation (1967).

Endrin Process

1. Function - Endrin is formed by the addition of isodrin to H_2O_2 and acetic acid in an epoxidation reaction.

2. Input Materials - Isodrin, hydrogen peroxide, and acetic acid.

3. Operating Parameters - Temperature: 20 to 45°C, mildly exothermic.
   - Pressure: Atmospheric.
   - Reaction time: Agitated at length, then heated to 45°C for 1 hr.
   - Phase: Benzene solvent.
   - Equipment: Stirred, jacketed tank.

4. Utilities - Data not available.

5. Waste Streams - Waste streams containing peracid, carboxylic acid and benzene are steam washed and discharged.

6. EPA Source Classification Code - None exists.

7. Reference -

Sittig, M., *Pesticide Production Processes 1967*, Noyes Data Corporation (1967).

Dieldrin Process

1. **Function** - Dieldrin is formed by the reaction of aldrin, hydrogen peroxide, and acetic acid. The steps of the process include a mixing stage, the reaction step, and product recovery.

   In the mixing stage, the H_2O_2 and CH_3COOH are mixed to form "per" acid and aldrin is dissolved in a toluene solution. These two solutions are combined in an oxidation reactor with H_2SO_4 as a catalyst. The dieldrin solution then is passed through normal extraction and solvent stripping steps.

   The waste streams from these process steps are sent to an evaporation basin.

2. **Input Materials** - Aldrin, hydrogen peroxide, and acetic acid.

3. **Operating Parameters**
   - Temperature: 0 to 75°C.
   - Pressure: Atmospheric.
   - Reaction time: 1 to 6 hr.
   - Equipment: Mixing tank, first-stage reactor, settling drum, second-stage reactor, third-stage epoxidation reactor. Acids and water soluble material are extracted with water. Raffinate goes to still to recover solvent and product.

4. **Utilities** - Data not available.

5. **Waste Streams** - Acids and water soluble materials are sent to an evaporation basin.

6. **EPA Source Classification Code** - None exists.

7. **References** -

Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

Sittig, M., Pesticide Production Processes 1967, Noyes Data Corporation (1967).

Chlordane Process

1. Function - Chlordane is produced by the chlorination of the intermediate chlordene. (See Figure 6, Process No. 9). The process involves three major steps: SO_2Cl_2 generation, the chlorination, and product recovery.

   In the first step, SO_2 and Cl_2 are combined to form sulfurylchloride. An excess of SO_2Cl_2 is then combined with chlordene in a chlorination reaction. The resultant product stream contains a mixture of chlordane, SO_2Cl_2 and SO_2. The chlordane is removed and processed, and the SO_2Cl_2 and SO_2 are recycled to the SO_2Cl_2 generation.

2. Input Materials - Chlordene (or hexachlorocyclopentadiene and cyclopentadiene) and Cl_2.

3. Operating Parameters - Temperature: ~ 69°C, reflux temperature of sulfurylchloride.
   - Pressure: Atmospheric.
   - Reaction time: 1 hr.
   - Equipment: Stirred, jacketed kettle equipped with reflux condenser.

4. Utilities - Data not available.

5. Waste Streams - Spent hypochlorite. Wastewater is 2% NaOH and 400 ppm hexachlorocyclopentadiene. This wastewater is deep-well injected at one plant.

6. EPA Source Classification Code - None exists.

7. References -

   Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Sittig, M., Pesticide Production Processes 1967, Noyes Data Corporation (1967).

Organophosphate Pesticides

The organophosphate pesticides are hydrocarbon compounds which contain one or more phosphorous atoms. The typical structure of acyclic organophosphate pesticides is illustrated in Table 4 along with a tabulation of many pesticides. Similarly, Table 5 presents the structure and tabulated cyclic organophosphate pesticides.

The organophosphates can be separated into three main groups: (a) those derived from phosphorus pentasulfide (P_2S_5), (b) those derived from thiophosphoryl chloride ($PSCl_3$), and (c) those derived from phosphorus trichloride (PCl_3). The chemical reactions and their relationships for key pesticides in these three groups are presented in Figures 7, 8, and 9, respectively.

Most organophosphates are used as insecticides with a few used as herbicides. The acyclic insecticides include methyl parathion at 13 million pounds and diazinon at 10 million pounds. The cyclic insecticides include malathion at 25 million pounds. The herbicides include DEF at 5 million pounds and merphos at 2 million pounds. The production of organophosphate pesticides has increased since 1972.

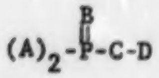
The flow sheets for the organophosphate pesticide processes are presented by groups in Figures 10 and 11. When similar reactions are involved and similar chemical structures are formed, the related pesticide processes are represented by one process block. Note that the pesticides formed from $PSCl_3$ can also be formed from P_2S_5 by simple chlorination of the P_2S_5 or the intermediate mercaptan chemicals. The process blocks are discussed in more detail in the individual process summaries that follow.

Data for several processes within this segment were not available, and detailed descriptions of these processes were not included. These processes include:

Dialkyl Phosphorodithioic Acids
Na Substitution Process
Chlorination Process
Cl Replacement Addition Process
Ronnel Process
Trichlorfan Process
Dichlorios Process
Naled Process
Organophosphate Addition Process
Chlorine Tri-Addition Organophosphate Process
P-Tri-Addition Merphos Process

Table 4. THE CHEMICAL STRUCTURE OF ACYCLIC ORGANOPHOSPHATE PESTICIDES

I. Monophosphorus

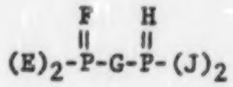

$$(A)_2\text{-}\overset{\overset{B}{\|}}{P}\text{-}C\text{-}D$$

Me = methyl
Et = ethyl

	A	B	C	D
(Systox) Demeton (mixture)	EtO	S	O	$CH_2CH_2SC_2H_5$
	EtO	O	S	$CH_2CH_2SC_2H_5$
Dichlorvos	MeO	O	O	$CH = CCl_2$
Dicrotophos	MeO	O	O	$C(CH_3) = CHCON(CH_3)_2$
Dimethoate	MeO	S	S	$CH_2CONHCH_3$
Disulfoton	EtO	S	S	$CH_2CH_2SC_2H_5$
Malathion	MeO	S	S	$CHCOOC_2H_5$ $CH_2COOC_2H_5$
Mevinphos	MeO	O	O	$C(CH_3) = CHCON(CH_3)_2$
Monitor	MeO and MeS	O	-	NH_2
Monocrotophos	MeO	O	O	$C(CH_3) = CHCONHCH_3$
Naled	MeO	O	O	$CHBrCBrCl_2$
Oxydemeton-methyl (mixture) (Meta-systox)	MeO	S	O	$CH_2CH_2SC_2H_5$
	MeO	O	S	$CH_2CH_2SC_2H_5$
Phorate (Thimet)	EtO	S	S	$CH_2SC_2H_5$
Phosphamidon	MeO	O	O	$C(CH_3) = CClCON(C_2H_5)_2$
Trichlorfon	MeO	O	-	$CH(OH)CCl_3$

Table 4. (Concluded)

II. Diphosphorus

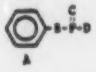


$$(E)_2-\overset{\overset{F}{\|}}{P}-G-\overset{\overset{H}{\|}}{P}-(J)_2$$

	E	F	G	H	I
Aspon	C_3H_7O	S	O	S	C_3H_7O
Ethion	EtO	S	SCH_2S	S	EtO
TEPP	EtO	O	O	O	EtO

Table 8. THE CHEMICAL STRUCTURE OF CYCLIC ORGANOPHOSPHATE PESTICIDES

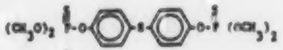
I. Substituted phenyls



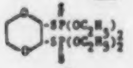
Pesticide	A	B	C	D
Carbophenothion	4-chlorophenyl	SCH_2S	S	$(OC_2H_5)_2$
Crotoxyphos	phenyl	$(CH_3)CHOOCCH = C(CH_3)O$	O	$(OCH_3)_2$
Crufomate	4-t-butyl-2-chlorophenyl	O	O	(1) OCH_3 (1) $NHCH_3$
Dyfonate (fonofos)	phenyl	S	S	(1) OC_2H_5 (1) C_2H_5
Fensulfothion (Dasanit)	4-(methylsulfinyl)phenyl	O	S	$(OC_2H_5)_2$
Fenthion	4-methylthio-m-cresol	O	S	$(OCH_3)_2$
Methyl parathion	4-nitrophenyl	O	S	$(OCH_3)_2$
Parathion	4-nitrophenyl	O	S	$(OC_2H_5)_2$
Fenchlorphos (Ronnel)	2,4,5-trichlorophenyl	O	S	$(OCH_3)_2$
Dicapthon	2-chloro-4-nitrophenyl	O	S	$(OCH_3)_2$
Famophos	N,N-dimethyl-phenyl-4-sulfonamide	O	S	$(OCH_3)_2$

II. Two diphosphorous compounds

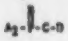
Abate



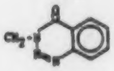
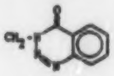
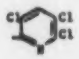
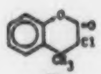
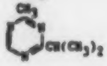
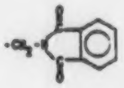
Dioxathion

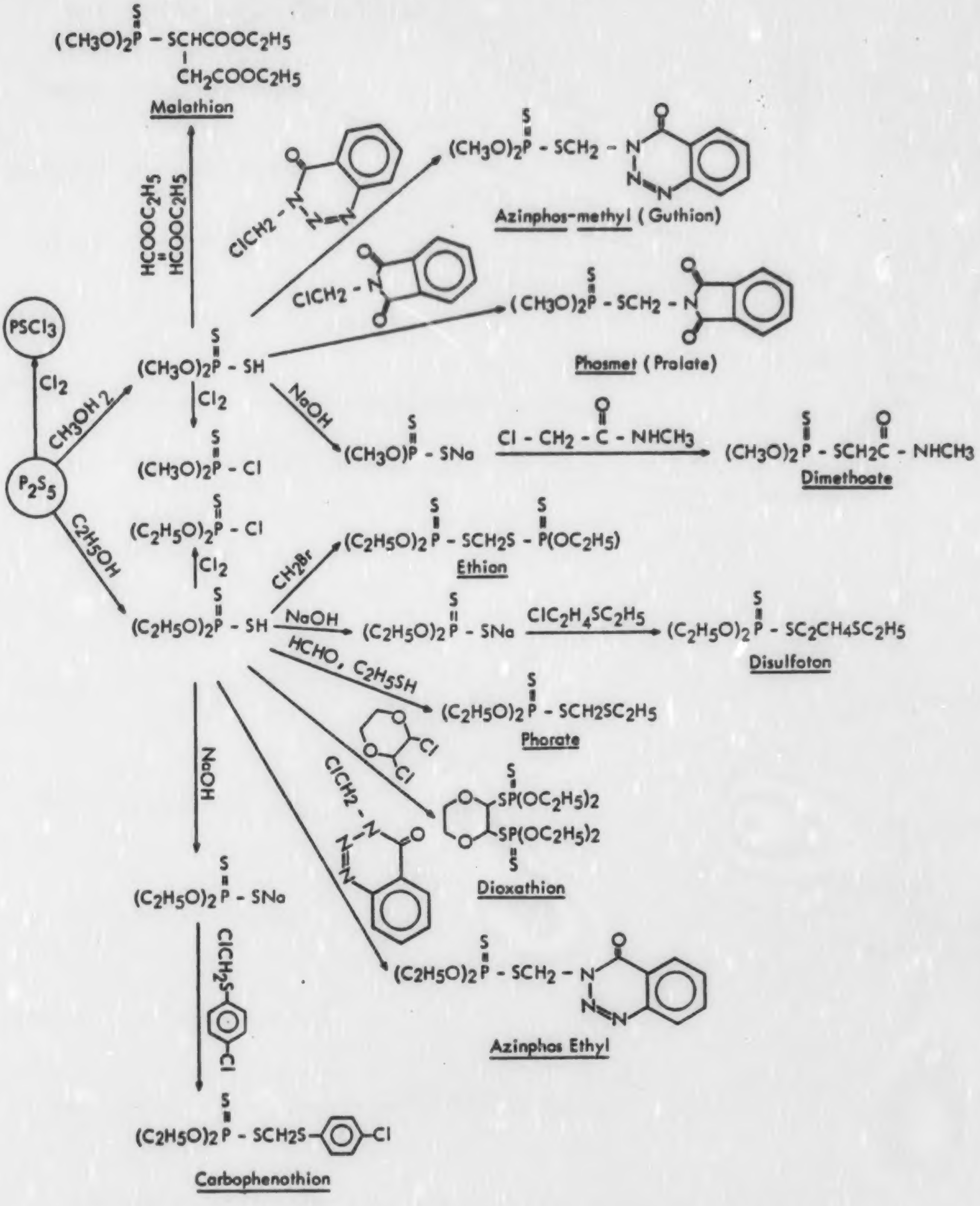


III. Other Cyclic Structures



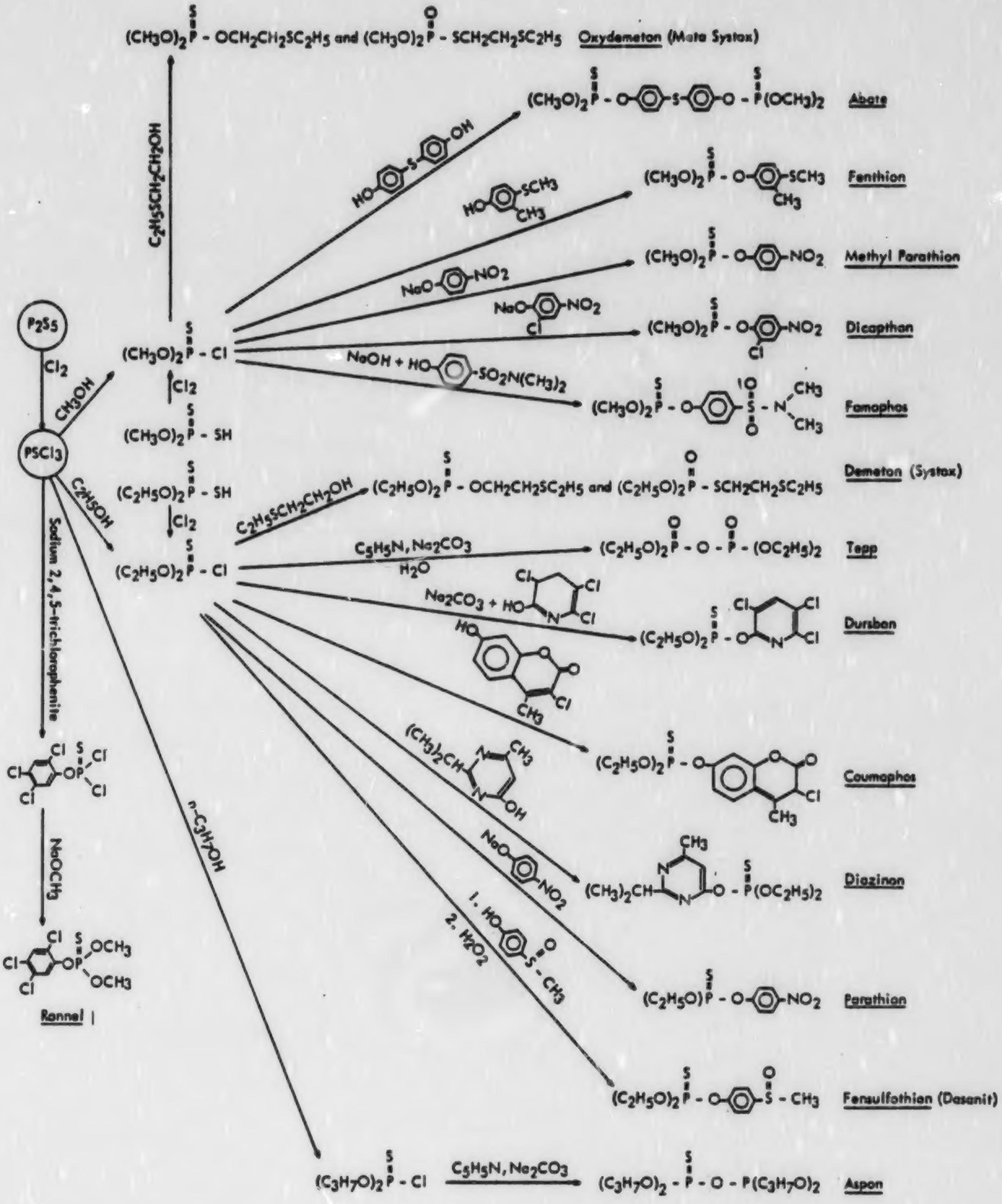
$A_2-\overset{B}{\overset{\|}{P}}-C-D$

	A	B	C	D
Azinphos-methyl (Guthion)	CH_3O	S	S	
Azinphos-ethyl	C_2H_5O	S	S	
Dursban	C_2H_5O	S	O	
Coumaphos	C_2H_5O	S	O	
Diazinon	C_2H_5O	S	O	
Phosmet (Imidan)	CH_3O	S	S	



(CH3O)2P(S) - SCHCOOC2H5 / CH2COOC2H5
Malathion
HCOOC2H5 = HCOOC2H5
ClCH2
(CH3O)2P(S) - SCH2 - N
Azinphos-methyl (Guthion)
ClCH2 - N
(CH3O)2P(S) - SCH2 - N
Phosmet (Prolate)
PSCl3
Cl2
CH3OH
(CH3O)2P(S) - SH
Cl2
NaOH
(CH3O)P(S) - SNa
Cl - CH2 - C(O) - NHCH3
(CH3O)2P(S) - SCH2C(O) - NHCH3
Dimethoate
(CH3O)2P(S) - Cl
P2S5
C2H5OH
(C2H5O)2P(S) - Cl
Cl2
CH2Br
(C2H5O)2P(S) - SCH2S - P(S)(OC2H5)
Ethion
(C2H5O)2P(S) - SH
NaOH
(C2H5O)2P(S) - SNa
ClC2H4SC2H5
(C2H5O)2P(S) - SC2CH4SC2H5
Disulfoton
HCHO, C2H5SH
(C2H5O)2P(S) - SCH2SC2H5
Phorate
Cl
Cl
SP(OC2H5)2
SP(OC2H5)2
Dioxathion
NaOH
ClCH2 - N
(C2H5O)2P(S) - SNa
ClCH2S
Cl
(C2H5O)2P(S) - SCH2 - N
Azinphos Ethyl
(C2H5O)2P(S) - SCH2S - Cl
Carbophenothion

Figure 7. Chemical reactions for organophosphate pesticides from phosphorus pentasulfide (P_2S_5)



(CH3O)2P(S) - OCH2CH2SC2H5 and (CH3O)2P(O) - SCH2CH2SC2H5 Oxydemeton (Meta Systox)
C2H5SCH2CH2OH
(CH3O)2P(S) - O-⟨⟩-S-⟨⟩-O - P(S)(OCH3)2 Abate
(CH3O)2P(S) - O-⟨⟩-SCH3 CH3 Fenthion
(CH3O)2P(S) - O-⟨⟩-NO2 Methyl Parathion
(CH3O)2P(S) - O-⟨⟩-NO2 Cl Dicapthon
NaOH + HO-⟨⟩-SO2N(CH3)2
(CH3O)2P(S) - O-⟨⟩-S(O)(O) - N(CH3)(CH3) Famophos
P2S5
Cl2
CH3OH
PSCl3
(CH3O)2P(S) - Cl
(CH3O)2P(S) - SH
C2H5OH
(C2H5O)2P(S) - SH
(C2H5O)2P(S) - Cl
C2H5SCH2CH2OH
(C2H5O)2P(S) - OCH2CH2SC2H5 and (C2H5O)2P(O) - SCH2CH2SC2H5 Demeton (Systox)
C5H5N, Na2CO3
H2O
(C2H5O)2P(O) - O - P(O) - (OC2H5)2 Tepp
Na2CO3 + HO
(C2H5O)2P(S) - O Dursban
(C2H5O)2P(S) - O Coumaphos
(CH3)2CH
(CH3)2CH - O - P(S)(OC2H5)2 Diazinon
NaO-⟨⟩-NO2
1. HO-⟨⟩-S(O) - CH3
2. H2O2
(C2H5O)P(S) - O-⟨⟩-NO2 Parathion
(C2H5O)2P(S) - O-⟨⟩-S(O) - CH3 Fensulfothion (Dasanit)
Sodium 2,4,5-trichlorophenite
NaOCH3
Ronnel
n-C3H7OH
(C3H7O)2P(S) - Cl
C5H5N, Na2CO3
(C3H7O)2 - P(S) - O - P(C3H7O)2 Aspon

Figure 8. Chemical reactions for organophosphate pesticides from phosphorus trichlorosulfide

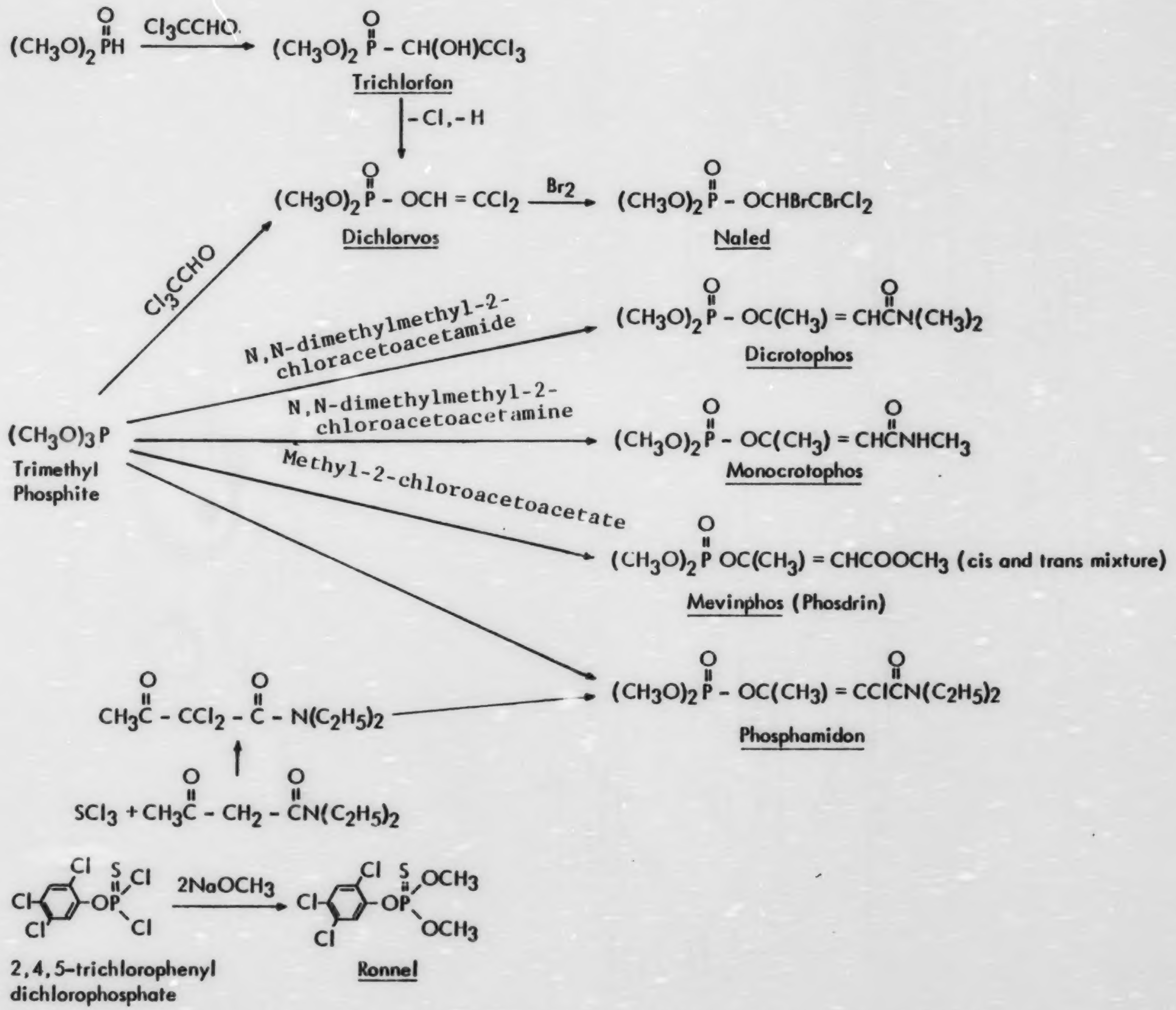

(CH3O)2PH
Cl3CCHO
(CH3O)2 P - CH(OH)CCl3
Trichlorfon
-Cl, -H
(CH3O)2 P - OCH = CCl2
Dichlorvos
Br2
(CH3O)2 P - OCHBrCBrCl2
Naled
Cl3CCHO
N,N-dimethylmethyl-2-chloracetoacetamide
(CH3O)2 P - OC(CH3) = CHCN(CH3)2
Dicrotophos
N,N-dimethylmethyl-2-chloroacetoacetamine
(CH3O)3 P
Trimethyl Phosphite
(CH3O)2 P - OC(CH3) = CHCNHCH3
Monocrotophos
Methyl-2-chloroacetoacetate
(CH3O)2 P OC(CH3) = CHCOOCH3 (cis and trans mixture)
Mevinphos (Phosdrin)
CH3C - CCl2 - C - N(C2H5)2
(CH3O)2 P - OC(CH3) = CClCN(C2H5)2
Phosphamidon
SCl3 + CH3C - CH2 - CN(C2H5)2
2NaOCH3
2,4,5-trichlorophenyl dichlorophosphate
Ronnel

Figure 9. Chemical reactions for organophosphate pesticides from other phosphorous compounds

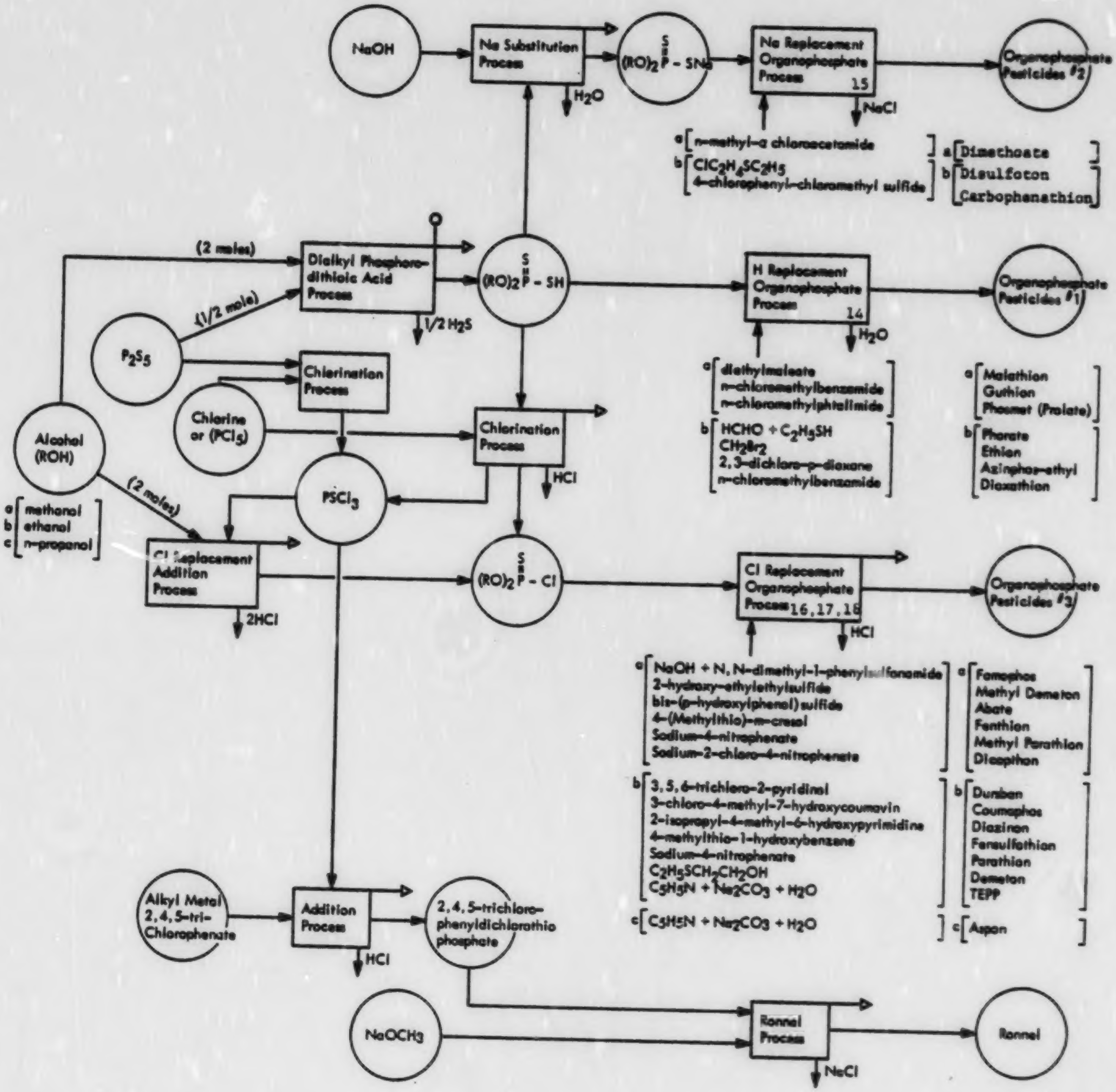
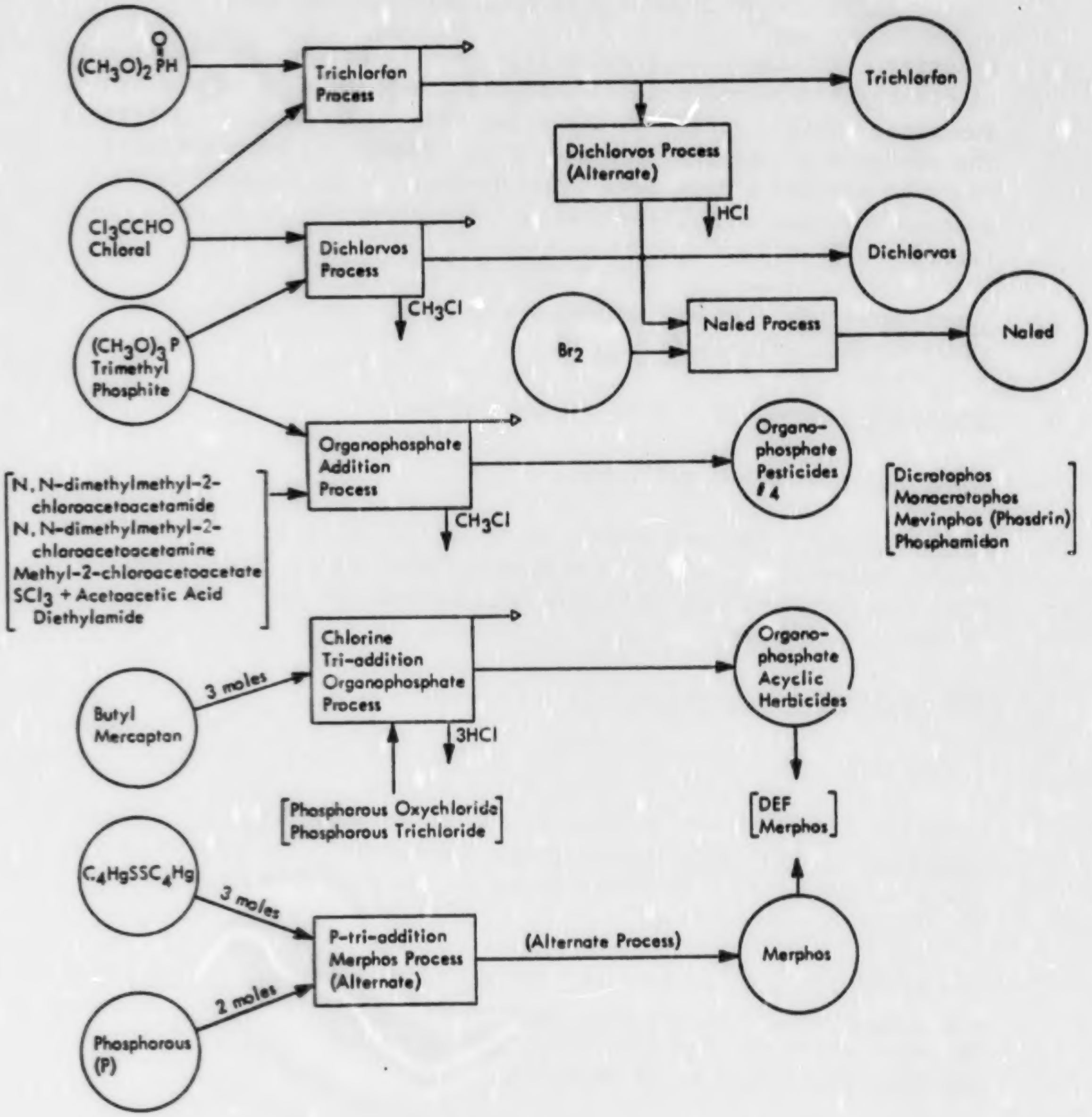

NaOH
Na Substitution Process
H2O
(RO)2 P(=S) - SNa
Na Replacement Organophosphate Process 15
NaCl
Organophosphate Pesticides #2
a [n-methyl-a chloroacetamide]
b [ClC2H4SC2H5
4-chlorophenyl-chloromethyl sulfide]
a [Dimethoate]
b [Disulfoton
Carbophenathion]
(2 moles)
Dialkyl Phosphorodithioic Acid Process
(1/2 mole)
1/2 H2S
(RO)2 P(=S) - SH
H Replacement Organophosphate Process 14
H2O
Organophosphate Pesticides #1
a [diethylmaleate
n-chloromethylbenzamide
n-chloromethylphtalimide]
b [HCHO + C2H5SH
CH2Br2
2,3-dichloro-p-dioxane
n-chloromethylbenzamide]
a [Malathion
Guthion
Phosmet (Prolate)]
b [Phorate
Ethion
Azinphos-ethyl
Dioxathion]
P2S5
Chlorination Process
Chlorine or (PCl5)
Chlorination Process
HCl
Alcohol (ROH)
a [methanol
b ethanol
c n-propanol]
(2 moles)
PSCl3
Cl Replacement Addition Process
2HCl
(RO)2 P(=S) - Cl
Cl Replacement Organophosphate Process 16,17,18
HCl
Organophosphate Pesticides #3
a [NaOH + N,N-dimethyl-1-phenylsulfonamide
2-hydroxy-ethylethylsulfide
bis-(p-hydroxylphenol) sulfide
4-(Methylthio)-m-cresol
Sodium-4-nitrophenate
Sodium-2-chloro-4-nitrophenate]
b [3,5,6-trichloro-2-pyridinol
3-chloro-4-methyl-7-hydroxycoumavin
2-isopropyl-4-methyl-6-hydroxypyrimidine
4-methylthio-1-hydroxybenzene
Sodium-4-nitrophenate
C2H5SCH2CH2OH
C5H5N + Na2CO3 + H2O]
c [C5H5N + Na2CO3 + H2O]
a [Famophos
Methyl Demeton
Abate
Fenthion
Methyl Parathion
Dicapthon]
b [Dursban
Coumaphos
Diazinon
Fensulfothion
Parathion
Demeton
TEPP]
c [Aspon]
Alkyl Metal 2,4,5-tri-Chlorophenate
Addition Process
HCl
2,4,5-trichlorophenyldichlorothiophosphate
NaOCH3
Ronnel Process
NaCl
Ronnel

Figure 10. Flow sheet for organophosphate pesticide processes



(CH3O)2 P(O)H
Trichlorfon Process
Trichlorfon
Dichlorvos Process (Alternate)
HCl
Cl3CCHO Chloral
Dichlorvos Process
Dichlorvos
CH3Cl
(CH3O)3 P Trimethyl Phosphite
Br2
Naled Process
Naled
Organophosphate Addition Process
Organophosphate Pesticides # 4
N, N-dimethylmethyl-2-chloroacetoacetamide
N, N-dimethylmethyl-2-chloroacetoacetamine
Methyl-2-chloroacetoacetate
SCl3 + Acetoacetic Acid Diethylamide
CH3Cl
Dicrotophos
Monocrotophos
Mevinphos (Phosdrin)
Phosphamidon
Butyl Mercaptan
3 moles
Chlorine Tri-addition Organophosphate Process
3HCl
Organophosphate Acyclic Herbicides
Phosphorous Oxychloride
Phosphorous Trichloride
DEF
Merphos
C4H9SSC4H9
3 moles
P-tri-addition Merphos Process (Alternate)
(Alternate Process)
Merphos
2 moles
Phosphorous (P)

Figure 11. Flow sheet for other organophosphate pesticide processes

H-Replacement Organophosphate Process, Malathion

1. Function - Malathion is manufactured in this process by the reaction of dimethylphosphorodithioic acid and diethylmaleate or diethylfumarate. This reaction is the first step in the malathion process. The products of the reaction are first passed through a stripper and then through a NaOH wash. The product is then passed through a steam stripper and filter from which technical malathion is obtained.

2. Input Materials - Dimethylphosphorodithioic and diethylmaleate (DEM) or diethylfumarate (DEF).

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - The gas stream contains H_2S which is processed for sulfur recovery. The liquid stream contains NaCl. The wastewater from the strippers and the waste stream from the NaOH wash is barged to sea at one plant.

6. EPA Source Classification Code - 3-01-033-01.

7. References -

Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Na Replacement Organophosphate Process, Disulfoton

1. Function - Disulfoton is produced by the reaction of sodium diethylphosphorodithioate (diethyl salt) and β-chloroethyl thioethyl ether (chloro thio alcohol). In the Chemagro plant at Kansas City, Missouri, where disulfoton is manufactured, intermediates are also produced.

   The diethyl salt and chloro thio ether are combined in the presence of NaOH in order to maintain caustic conditions. The reaction proceeds according to the equation:

   $$(C_2H_5O)_2P(S)SNa + ClC_2H_4\text{-}S\text{-}C_2H_5 \rightarrow (C_2H_5O)_2P(S)\text{-}S\text{-}C_2H_4\text{-}S\text{-}C_2H_5 + NaCl$$

   The disulfoton is then recovered. The intermediates are also recovered and recycled to the reaction.

2. Input Materials - Sodium diethylphosphorodithioate and β-chloroethyl thioethyl ether.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - Gas: H_2S to flare. Vents to atmosphere.
   - Liquids: Triester and organic skimmings to burial. Process wastewater to toluene extractor and skimmer with final NaOH and NaOCl treatment before flowing to the wastewater treatment plant. Caustic conditions (lime) remove some of the organophosphates during a retention period of 36 hr. The pH is also adjusted and polyelectrolyte flocculents added. The effluent is discharged into the Blue River with contaminants in the parts per million range.

6. EPA Source Classification Code - None exists.

7. References -

Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Sittig, M., Pesticide Production Processes 1967, Noyes Data Corporation, Park Ridge, New Jersey (1967).

Cl Replacement Organophosphate Process, Methyl Parathion

1. Function - Methyl parathion is produced by the reaction of o,o-dimethylphosphorochloridothionate and sodium p-nitro-phenoxide in a batch process. The reaction of the chloridothionate and $NaOC_6H_4NO_2$ in the presence of acetone yields parathion and a waste stream containing NaCl. The waste stream is treated with Na_2CO_3.

2. Input Materials - o,o-Dimethylphosphorochloridothionate and sodium p-nitro-phenoxide.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - Liquid wastes from one plant, including by-product HCl-NaCl, go to biological treatment facilities and then into a sewer system. By-product H_2S is flared, sulfur and waste solvent are burned. The only solid waste is sludge from the biological oxidation system which is recycled and discharged at a slow rate into the sewer. Spills are washed into the waste treatment system.

6. EPA Source Classification Code - None exists.

7. References -

Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Cl Replacement Organophosphate Process, Parathion

1. Function - Parathion, a liquid organophosphate pesticide, is produced by the reaction of diethylphosphorochloridothionate and sodium *p*-nitrophenate. At least one producer (Monsanto) uses the same equipment for parathion as used for methyl parathion production (see the preceding process description for methyl parathion).

2. Input Materials - Diethylphosphorochloridothionate and sodium *p*-nitrophenate.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - The waste streams from parathion manufacture may contain sulfur, HCl, sodium chloride, sodium carbamate, trimethyl thiophosphate, and other organics including paranitrophenol and small amounts of product. A typical waste stream can be characterized by:

COD	3,000 mg/l
BOD	700
Total Solids	27,000
pH	2.0
Acidity	3,000
Sodium	6,000
Chlorides	7,000
Phosphates	250
Nitrates	20
Sulfates	3,000
Parathion	20
Calcium	High

Gaseous emissions from parathion production contain significant amounts of mercaptans including hydrogen sulfide. Concentrated residues and tank bottoms must also be handled since they contain large amounts of intermediates and some product. This portion of the waste may be a slurry with a paste-like consistency which poses severe handling problems but seldom enters the wastewater stream.

6. EPA Source Classification Code - None exists

7. References -

Atkins, Patrick R., The Pesticide Manufacturing Industry-Current Waste Treatment and Disposal Practices, for U.S. EPA, Office of Research and Monitoring, Project No. 12020 FYE, January 1972.

Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972. NTIS Publication PB 213-782/3.

Cl Replacement Organophosphate Process, Diazinon

1. Function - Diazinon is produced by the reaction of diethylphosphorochloridothionate $[(C_2H_5O)_2P(S)Cl]$ and 2-isopropyl-4-methyl-6-hydroxpyrimidene with Na_2CO_3. The process consists of two reaction steps, a purification and recovery step, and the waste treatment system.

   The first reaction is a coupling reaction between the pyrimidene and the $(C_2H_5O)_2P(S)Cl$, which is in a solvent such as toluene, benzene or dioxane. The product of this reaction is then combined with Na_2CO_3 in a purification and filtration step. The product stream then passes to a stripper and then a filtration step for collection of the diazinon product.

2. Input Materials - Diethylphosphorochloridothionate, 2-isopropyl-4-methyl-6-hydroxpyrimidene, and Na_2CO_3.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - The two major waste streams from this process are at the filtration steps. At one plant, the first waste stream containing NaCl and $NaHCO_3$ is deep well injected. The waste stream from final filtration contains other organophosphates and is further processed.

6. EPA Source Classification Code - None exists.

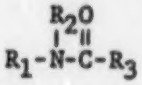
7. Reference -

   von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Enviromental Quality, Contract EQC-311, Final Report, 15 March 1974.

Carbamate Pesticides

The carbamate family of pesticides includes over 30 pesticides with the characteristic carbamate carbon-nitrogen structure (-N-C-). This family can be separated into three groups: (a) the carbamate pesticides; (b) the thiocarbamate pesticides; and (c) the dithiocarbamate acid salt pesticides.

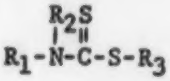
The structure of the major carbamate and thiocarbamate pesticides is:



$$R_1-\overset{R_2}{\overset{|}{N}}-\overset{O}{\overset{\|}{C}}-R_3$$

as summarized in Table 6.

The dithiocarbamate acid salts have the characteristic carbamate structure with two sulfur atoms added:



$$R_1-\overset{R_2}{\overset{|}{N}}-\overset{S}{\overset{\|}{C}}-S-R_3$$

as summarized below.

Pesticide	R_1*	R_2*	R_3*
CDEC	$-C_2H_5$	$-C_2H_5$	$-CH_2CCl=CH_2$
Dimethyl dithiocarbamic acid, K salt	$-CH_3$	$-CH_3$	-K
Dimethyl dithiocarbamic acid, Mn salt	$-CH_3$	$-CH_3$	=Mn
Ethylene bis(dithiocarbamic acid), ammonia salt	$=C_2H_4$	-H	$-NH_4$
Ferbam	$-CH_3$	$-CH_3$	$=Fe_3$
Maneb	$=C_2H_4$	-H	=Mn
Metham-sodium	$-CH_3$	-H	-Na
Nabam	$=C_2H_4$	-H	$-NH_4$
Zineb	$=C_2H_4$	-H	=Zn

The production of the carbamate family of pesticides in 1972 was estimated at over 132 million pounds. The carbamate insecticides included carbaryl at 53 million pounds and carbofuran at 6 million pounds. The thiocarbamate herbicides included butylate at 6 million pounds and EPTC

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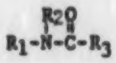
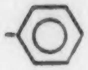
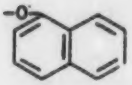
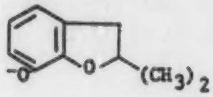
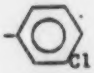
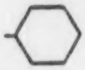
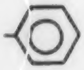
* Two of three bonds indicates connection with two or three thiocarbamate groups (i.e., "$=C_2H_4$" indicates "C_2H_4(thiocarbamic acid salt group)$_2$").

Table 6. STRUCTURE OF CARBAMATE AND THIOCARBAMATE PESTICIDES



$$R_1-\overset{R_2}{N}-\overset{O}{C}-R_3$$

Pesticide	R_1	R_2	R_3*
Aldicarb	$-CH_3$	-H	$-ON=CH-(CH_3)_2SCCH_3$
Barban		-H	$-OCH_2C=CCH_2Cl$
Butylate	$-CH_2CH(CH_3)_2$	$-CH_2CH(CH_3)_2$	$-SC_2H_5$
Carbaryl	$-CH_3$	-H	
Carbofuran	$-CH_3$	-H	
Chloropropham		-H	$-OCH(CH_3)_2$
Cycloate		$-C_2H_5$	$-SC_2H_5$
Di-Allate	$-CH(CH_3)_2$	$-CH(CH_3)_2$	$-SCH_2CCl=CHCl$
EPTC	$-C_3H_7$	$-C_3H_7$	$-SC_2H_5$
Metalkamate			
Molinate	(1)——hexamethyl——(2)		$-SC_2H_5$
Pebulate	$-nC_4H_9$	$-C_2H_5$	$-SC_3H_7$
Propham		-H	$-CH(CH_3)_2$
Tri-Allate	$-CH(CH_3)_2$	$-CH(CH_3)_2$	$-SCH_2CCl=CCl_2$
Vernolate	$-nC_3H_7$	$-nC_3H_7$	$-SC_3H_7$

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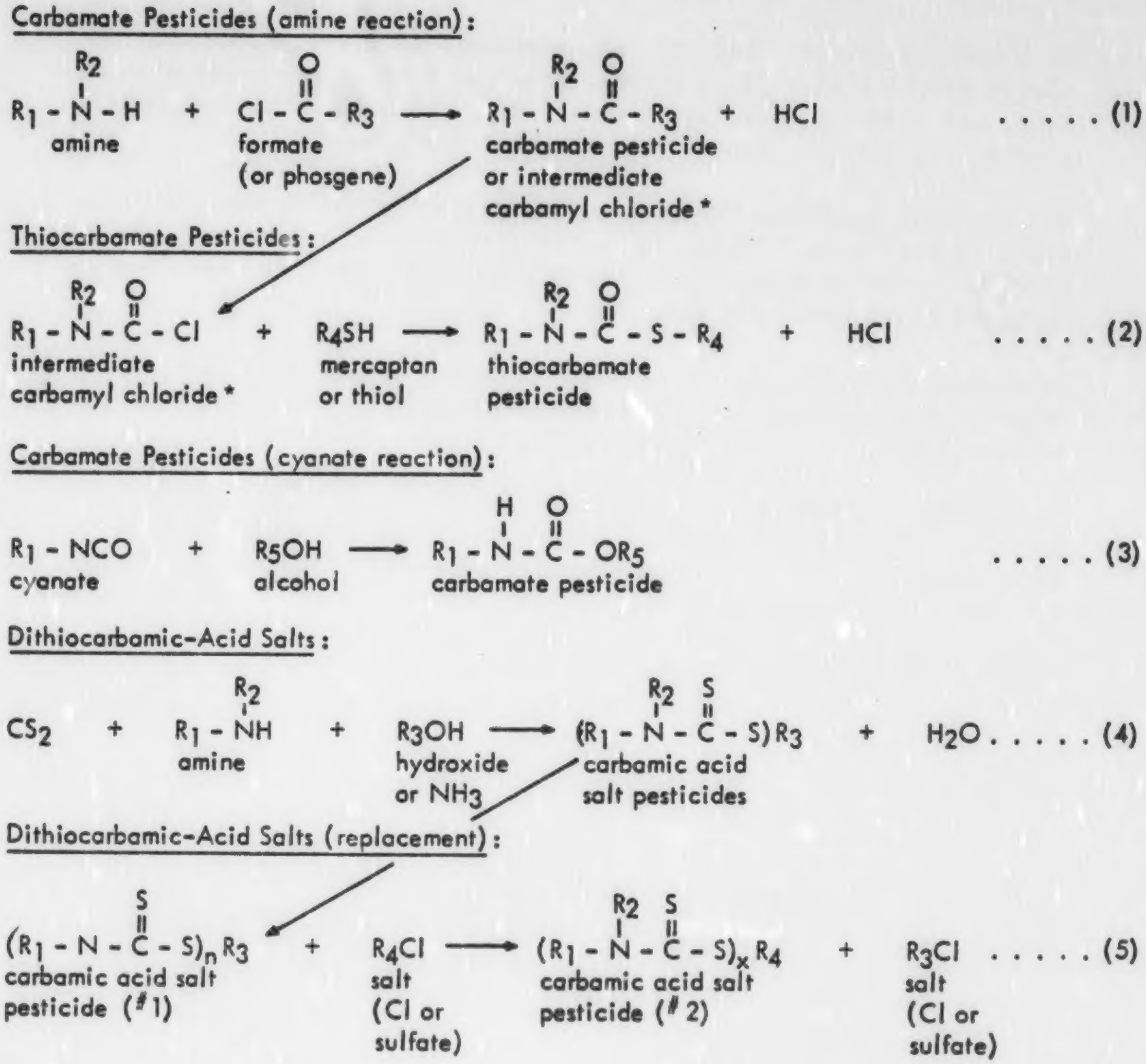
* Pesticides with S in the R_3 group are thiocarbamates.

at 5 million pounds. And the dithiocarbamic acid salt fungicides included maneb at 15 million pounds, zineb at 8 million, metham at 5 million, and nabam at 4 million pounds. The carbamate family production growth rate appears stable with potential for growth.

The chemical reactions for most carbamate-family pesticides are indicated in Figure 12. Figure 13 is the flow sheet for carbamate and thiocarbamate pesticide processes, and Figure 14 is the flow sheet for the dithiocarbamic acid salt processes.

Data were not available for several processes within this industry segment, and detailed process descriptions were not prepared. Those processes are:

Thiocarbamate Process
Carbamic Acid Salt Process
CDEC Process



Carbamate Pesticides (amine reaction):

$$\underset{\text{amine}}{R_1-\overset{R_2}{\overset{|}{N}}-H} + \underset{\text{formate (or phosgene)}}{Cl-\overset{O}{\overset{\|}{C}}-R_3} \longrightarrow \underset{\text{carbamate pesticide or intermediate carbamyl chloride *}}{R_1-\overset{R_2}{\overset{|}{N}}-\overset{O}{\overset{\|}{C}}-R_3} + HCl \quad .....(1)$$

Thiocarbamate Pesticides:

$$\underset{\text{intermediate carbamyl chloride *}}{R_1-\overset{R_2}{\overset{|}{N}}-\overset{O}{\overset{\|}{C}}-Cl} + \underset{\text{mercaptan or thiol}}{R_4SH} \longrightarrow \underset{\text{thiocarbamate pesticide}}{R_1-\overset{R_2}{\overset{|}{N}}-\overset{O}{\overset{\|}{C}}-S-R_4} + HCl \quad .....(2)$$

Carbamate Pesticides (cyanate reaction):

$$\underset{\text{cyanate}}{R_1-NCO} + \underset{\text{alcohol}}{R_5OH} \longrightarrow \underset{\text{carbamate pesticide}}{R_1-\overset{H}{\overset{|}{N}}-\overset{O}{\overset{\|}{C}}-OR_5} \quad .....(3)$$

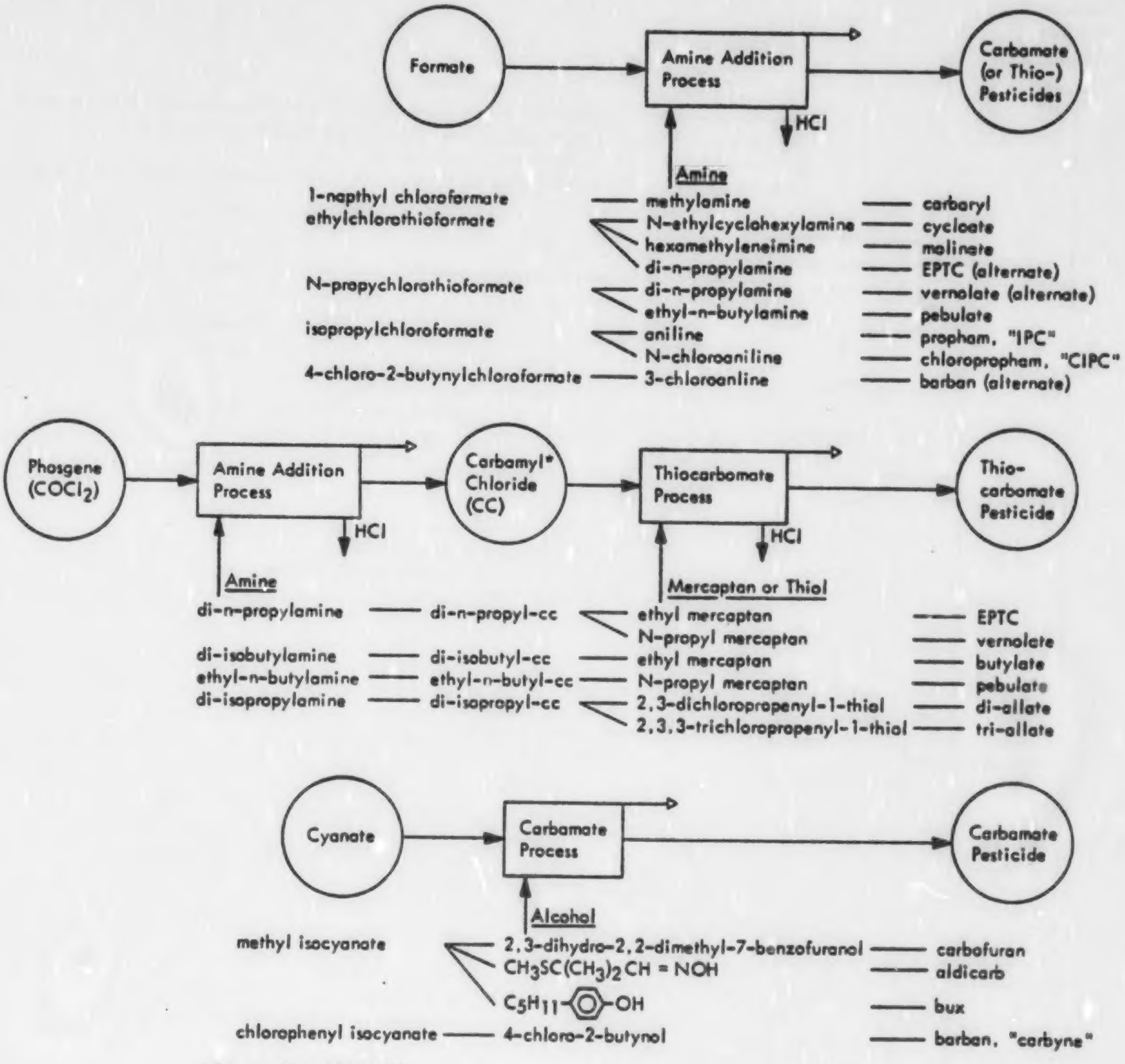
Dithiocarbamic-Acid Salts:

$$CS_2 + \underset{\text{amine}}{R_1-\overset{R_2}{\overset{|}{N}}H} + \underset{\text{hydroxide or } NH_3}{R_3OH} \longrightarrow \underset{\text{carbamic acid salt pesticides}}{(R_1-\overset{R_2}{\overset{|}{N}}-\overset{S}{\overset{\|}{C}}-S)R_3} + H_2O \quad .....(4)$$

Dithiocarbamic-Acid Salts (replacement):

$$\underset{\text{carbamic acid salt pesticide (\#1)}}{(R_1-N-\overset{S}{\overset{\|}{C}}-S)_nR_3} + \underset{\text{salt (Cl or sulfate)}}{R_4Cl} \longrightarrow \underset{\text{carbamic acid salt pesticide (\#2)}}{(R_1-\overset{R_2}{\overset{|}{N}}-\overset{S}{\overset{\|}{C}}-S)_xR_4} + \underset{\text{salt (Cl or sulfate)}}{R_3Cl} \quad .....(5)$$

Figure 12. Typical chemical reactions to produce carbamate pesticides


Formate
Amine Addition Process
HCl
Carbamate (or Thio-) Pesticides
Amine
1-napthyl chloroformate
ethylchlorothioformate
N-propychlorothioformate
isopropylchloroformate
4-chloro-2-butynylchloroformate
methylamine
N-ethylcyclohexylamine
hexamethyleneimine
di-n-propylamine
di-n-propylamine
ethyl-n-butylamine
aniline
N-chloroaniline
3-chloroaniline
carbaryl
cycloate
molinate
EPTC (alternate)
vernolate (alternate)
pebulate
propham, "IPC"
chloropropham, "CIPC"
barban (alternate)
Phosgene (COCl2)
Amine Addition Process
HCl
Carbamyl* Chloride (CC)
Thiocarbamate Process
HCl
Thio-carbamate Pesticide
Amine
di-n-propylamine
di-isobutylamine
ethyl-n-butylamine
di-isopropylamine
di-n-propyl-cc
di-isobutyl-cc
ethyl-n-butyl-cc
di-isopropyl-cc
Mercaptan or Thiol
ethyl mercaptan
N-propyl mercaptan
ethyl mercaptan
N-propyl mercaptan
2,3-dichloropropenyl-1-thiol
2,3,3-trichloropropenyl-1-thiol
EPTC
vernolate
butylate
pebulate
di-allate
tri-allate
Cyanate
Carbamate Process
Carbamate Pesticide
Alcohol
methyl isocyanate
chlorophenyl isocyanate
2,3-dihydro-2,2-dimethyl-7-benzofuranol
CH3SC(CH3)2CH = NOH
C5H11-⌬-OH
4-chloro-2-butynol
carbofuran
aldicarb
bux
barban, "carbyne"

* Intermediate Chemicals

Figure 13. Flow sheet for carbamate pesticide processes

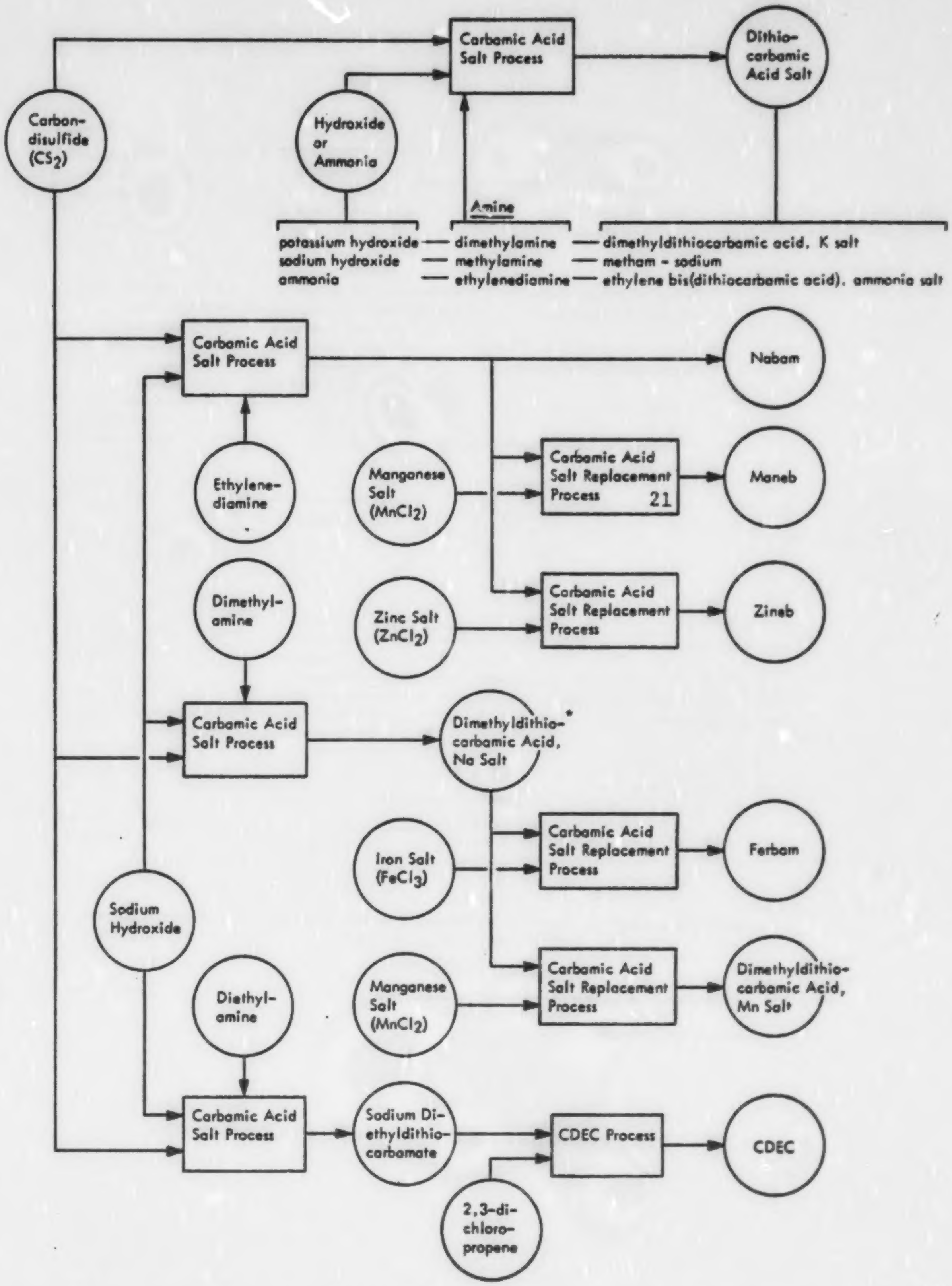
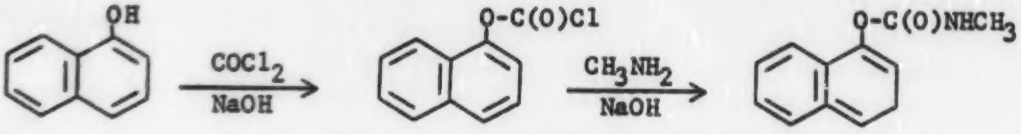

Carbamic Acid Salt Process
Dithiocarbamic Acid Salt
Carbondisulfide (CS_2)
Hydroxide or Ammonia
Amine
potassium hydroxide — dimethylamine — dimethyldithiocarbamic acid, K salt
sodium hydroxide — methylamine — metham - sodium
ammonia — ethylenediamine — ethylene bis(dithiocarbamic acid), ammonia salt
Carbamic Acid Salt Process
Nabam
Ethylenediamine
Manganese Salt ($MnCl_2$)
Carbamic Acid Salt Replacement Process
21
Maneb
Dimethylamine
Zinc Salt ($ZnCl_2$)
Carbamic Acid Salt Replacement Process
Zineb
Carbamic Acid Salt Process
Dimethyldithiocarbamic Acid, Na Salt*
Iron Salt ($FeCl_3$)
Carbamic Acid Salt Replacement Process
Ferbam
Sodium Hydroxide
Diethylamine
Manganese Salt ($MnCl_2$)
Carbamic Acid Salt Replacement Process
Dimethyldithiocarbamic Acid, Mn Salt
Carbamic Acid Salt Process
Sodium Diethyldithiocarbamate
CDEC Process
CDEC
2,3-dichloropropene

Figure 14. Flow sheet for dithiocarbamic acid salt pesticide processes

Amine Addition Process, Carbaryl

1. Function - Carbaryl is produced by the reaction of 1-naphthol, $COCl_2$, NaOH, and methylamine. The process consists of two reaction steps, a product recovery step and waste removal.

   The first reaction step combines naphthol, NaOH, and $COCl_2$ to form 1-naphthyl-chloroformate and waste NaCl. The naphthyl-chloroformate is then introduced with NaOH and CH_3NH_2 to the carbaryl unit. This reaction produces carbaryl and NaCl waste. The reaction chemistry for this process is:



1-Naphthol 1-Naphthyl-chloroformate Carbaryl

   The carbaryl is then dried and packaged.

2. Input Materials - 1-Naphthol, $COCl_2$, NaOH, and methylamine.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - Considerable care, through the use of special scrubbers and by enforcing safety precautions, must be taken to ensure that phosgene does not escape to the atmosphere. Wastewaters contain high total solids but almost no suspended solids and little pesticidal compounds. A typical waste stream from carbamate manufacture will contain:

COD	10,000 mg/l
BOD_5	Nil
Total Solids	40,000
pH	7-10
Suspended Solids	Nil
Sodium	8,000

Chlorides	100 mg/l
Phosphates	Nil
Organic Nitrogen	500
Sulfates	20,000
Product	Nil
Toxicity	Low
Flow per pound of product	Not available

At one plant, all pesticide-containing wastewater goes to the plant's secondary waste treatment system and then to a river. This effluent contains only 0.01 to 1 ppm carbaryl. Toxic vents are either flared or go to NaOH scrubbers. Nontoxic vents go to a condenser and are then vented to the atmosphere. Standard hoods are used in the packaging area and the recovered material is recycled. The heavy residue solid wastes are burned. One shutdown for cleaning is made per year, but numerous maintenance clean-ups are made and the washings go to the process waste treatment system.

6. EPA Source Classification Code - None exists.

7. References -

Atkins, Patrick R., The Pesticide Manufacturing Industry-Current Waste Treatment and Disposal Practices, for U.S. EPA, Office of Research and Monitoring, Project No. 12020 FYE, January 1972.

Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972. NTIS Publication PB 213-782/3.

Carbamate Process, Carbofuran

1. Function - Carbofuran is produced by the reaction of 2,3-dihydro-2,2-dimethyl-7-benzofuranol and methyl isocyanate. The process consists of the reaction of these two chemicals in the presence of ether and $(CH_3)_3N$. The carbofuran is recovered from the products, and the waste stream goes through neutralization, concentration equalization, and settling before discharge.

2. Input Materials - 2,3-Dihydro-2,2-dimethyl-7-benzofuranol and methyl isocyanate.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - Data not available.

6. EPA Source Classification Code - None exists.

7. Reference -

   von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Carbamic Acid Salt Replacement Process, Maneb

1. Function - Maneb is produced by the reaction of nabam and manganese-sulfate. A concentrated nabam solution is reacted with manganese-sulfate, and the desired manganese ethylenebisdithiocarbamate is precipitated. The slurry is washed with water to remove sodium sulfate and dried to less than 1% water content. Process by-products include sodium sulfate and small amounts of carbon disulfide and sodium hydroxide.

2. Input Materials - Nabam and manganese sulfate.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - At one plant, liquid sulfidic wastes containing Na_2SO_4 are discharged to a municipal sewer system. Air emissions are filtered and the resultant collected dust is landfilled.

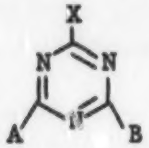
6. EPA Source Classification Code - None exists.

7. Reference -

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Triazine Pesticides

The derivatives of s-triazine form an important class of herbicides. Atrazine is by far the most widely used of all herbicides today. Dyrene is used as a fungicide. The general structure is:



where A and B are normally amine groups and X a less basic group as shown below. (Note: Numbering of the substituents is in alphabetical order, e.g., 2-chloro but 6-methoxy with i-PrNH-groups at A and B .)

	A	B	X
Ametryne®	EtNH-	i-PrNH-	$-SCH_3$
Atratone	EtNH-	i-PrNH-	$-OCH_3$
Atrazine	EtNH-	i-PrNH-	-Cl
Bladex®	EtNH-	$(CH_3)_2C(CN)NH-$	-Cl
Chlorazine	Et_2N-	Et_2N-	-Cl
Cyprazine	CH_2CH_2CHN-	$(CH_3)_2CHNH-$	-Cl
Dyrene®	ClC_6H_4NH-	Cl-	-Cl
Igran 80W®(terbutryne)	EtNH-	$(CH_3)_3CNH-$	$-SCH_3$
MPMT	$CH_3O(CH_2)_3NH-$	$CH_3O(CH_2)_3NH-$	$-SCH_3$
Prometone	i-PrNH-	i-PrNH-	$-OCH_3$
Prometryne	i-PrNH-	i-PrNH-	$-SCH_3$
Propazine	i-PrNH-	i-PrNH-	-Cl
Simazine	EtNH-	EtNH-	-Cl
Trietazine	EtNH-	EtNH-	-Cl

The estimated U.S. annual production of triazine pesticides is about 110 million pounds. Atrazine is by far the most important pesticide in this family with a current U.S. annual production of 95 million pounds. Atrazine is produced by a continuous process. The intermediate step of forming cyanuric ethylamine is combined in the amination unit in the continuous process (shown in Process 56 in Figure 16). Other triazine pesticides can be made in the same facility as atrazine. The growth trend for the triazine pesticides is up slightly as new applications and mixtures are approved for atrazine.

Cyanuric chloride is reacted with appropriate amino hydrocarbons to obtain the different triazine pesticides. Reaction sequences for selected triazine pesticides are shown in Figure 15. A general process flow sheet for the synthesis of triazine pesticides is presented in Figure 16. The cyanuric chloride is produced from hydrogen cyanide and chlorine as described by Sittig.[57] The cyanuric chloride unit and all other triazine pesticide processes include a water wash of the pesticide product.

Data were not available on several processes within this industry segment. These processes for which descriptions are not included are:

Cyanuric Chloride Process
Dyrene Process
Cyanuric Ethylamine Process
Ametryne Process
Terbutryne Process
Propazine Process
Prometone Process
Prometryne Process

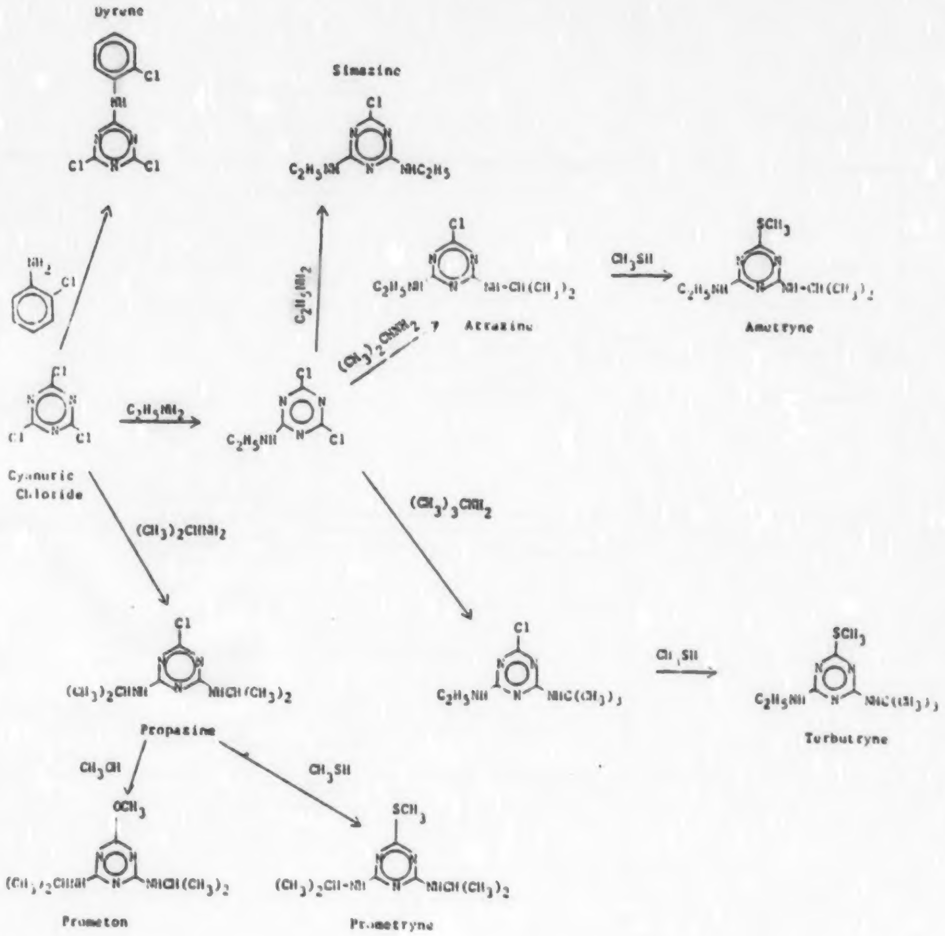
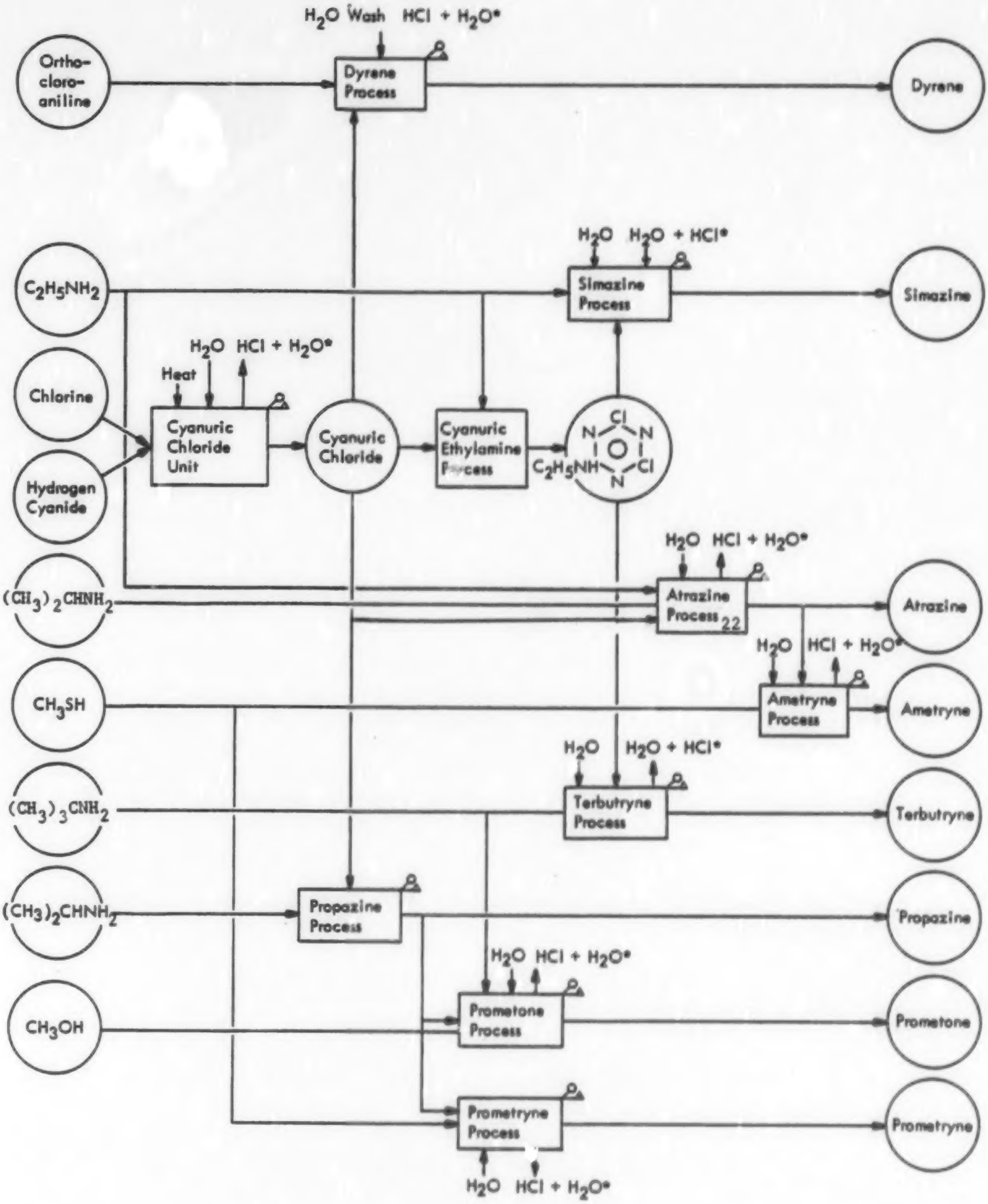

Dyrene
Simazine
Atrazine
Ametryne
Cyanuric Chloride
Propazine
Terbutryne
Prometon
Prometryne
C2H5NH2
(CH3)2CHNH2
(CH3)3CNH2
CH3SH
CH3OH

Figure 15. Synthesis of triazine pesticides


H₂O Wash
HCl + H₂O*
Ortho-cloro-aniline
Dyrene Process
Dyrene
H₂O
H₂O + HCl*
C₂H₅NH₂
Simazine Process
Simazine
H₂O
HCl + H₂O*
Heat
Chlorine
Cyanuric Chloride Unit
Cyanuric Chloride
Cyanuric Ethylamine Process
Cl
N
N
C₂H₅NH
N
Cl
Hydrogen Cyanide
H₂O
HCl + H₂O*
(CH₃)₂CHNH₂
Atrazine Process
22
Atrazine
H₂O
HCl + H₂O*
CH₃SH
Ametryne Process
Ametryne
H₂O
H₂O + HCl*
(CH₃)₃CNH₂
Terbutryne Process
Terbutryne
(CH₃)₂CHNH₂
Propazine Process
Propazine
H₂O
HCl + H₂O*
CH₃OH
Prometone Process
Prometone
Prometryne Process
Prometryne
H₂O
HCl + H₂O*

*HCl + H_2O to pH Control Unit with NaOH, then to wastewater treatment.

Figure 16. Flow sheet for triazine pesticide processes

TRIAZINE PESTICIDES PROCESS NO. 22

Atrazine Process

1. Function - Atrazine is produced in a continuous process by the reaction of cyanuric chloride, ethylamine, and $(CH_3)_2CHNH_2$. The process consists of the continuous reaction step, product recovery, and waste handling.

   In the reaction step, the ethylamine, $(CH_3)_2CHNH_2$ and a solvent are added to the cyanuric chloride. The solvent is removed from the unit and recycled to the process. The product stream is passed through a filter and on to the atrazine formulation unit. Here any additives or solvents are combined with the atrazine and the final product is then packaged.

2. Input Materials - Cyanuric chloride, ethylamine, and $(CH_3)CHNH_2$.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - The gaseous waste stream is scrubbed to remove HCl. Scrubber water as well as the liquid wastes from the filtration and formulation are treated and then discharged to a river.

   Sanitary wastes from the plant are chlorinated before they are discharged. The BOD of the waste going to the river is 500 lb/day at the 100 million pounds per year production rate.

   Dusts are emitted in the formulation and packaging areas. Losses are estimated to be less than 1%. Fabric filters or wet scrubbers are employed to control dust emissions.

6. EPA Source Classification Code - None exists.

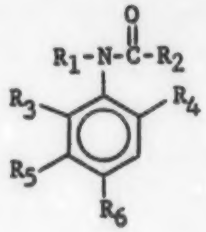
7. References -

   Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

   von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Anilide Pesticides

The anilide pesticides are a small group of four important herbicides. These pesticides are derived from aniline with a general structure as follows:



Pesticide	R_1	R_2	R_3	R_4	R_5	R_6
Alachlor	CH_3OCH_2	CH_2Cl	C_2H_5	C_2H_5	H	H
Butachlor	$C_4H_9OCH_2$	CH_2Cl	C_2H_5	C_2H_5	H	H
Propachlor	$(CH_3)_2CH$	CH_2Cl	H	H	H	H
Propanil	H	C_2H_5	H	H	Cl	Cl

The production of this small group of four anilide pesticides was estimated at 71 million pounds in 1972 with individual production of alachlor at 24 million pounds, butachlor at 5 million pounds, propachlor at 35 million pounds and propanil at 7 million pounds. Propanil is the oldest herbicide of the group, having been introduced in 1960 by Rohm and Haas. The other three pesticides have been introduced since 1965 by the Monsanto Company (Monsanto also makes propanil). The growth trend in these pesticides is upward with large gains possible for butachlor (introduced in 1969).

The chemical reaction sequences for synthesis of these pesticides are presented in Figure 17, and a process flow sheet is shown in Figure 18. The chemical reactions indicated for alachlor, butachlor, and propachlor are based on information obtained from Monsanto.

Detailed data were not available for some of the processes within this industry segment. Therefore, detailed process descriptions were not prepared for the following processes:

Aniline Addition Process
Propanil Process

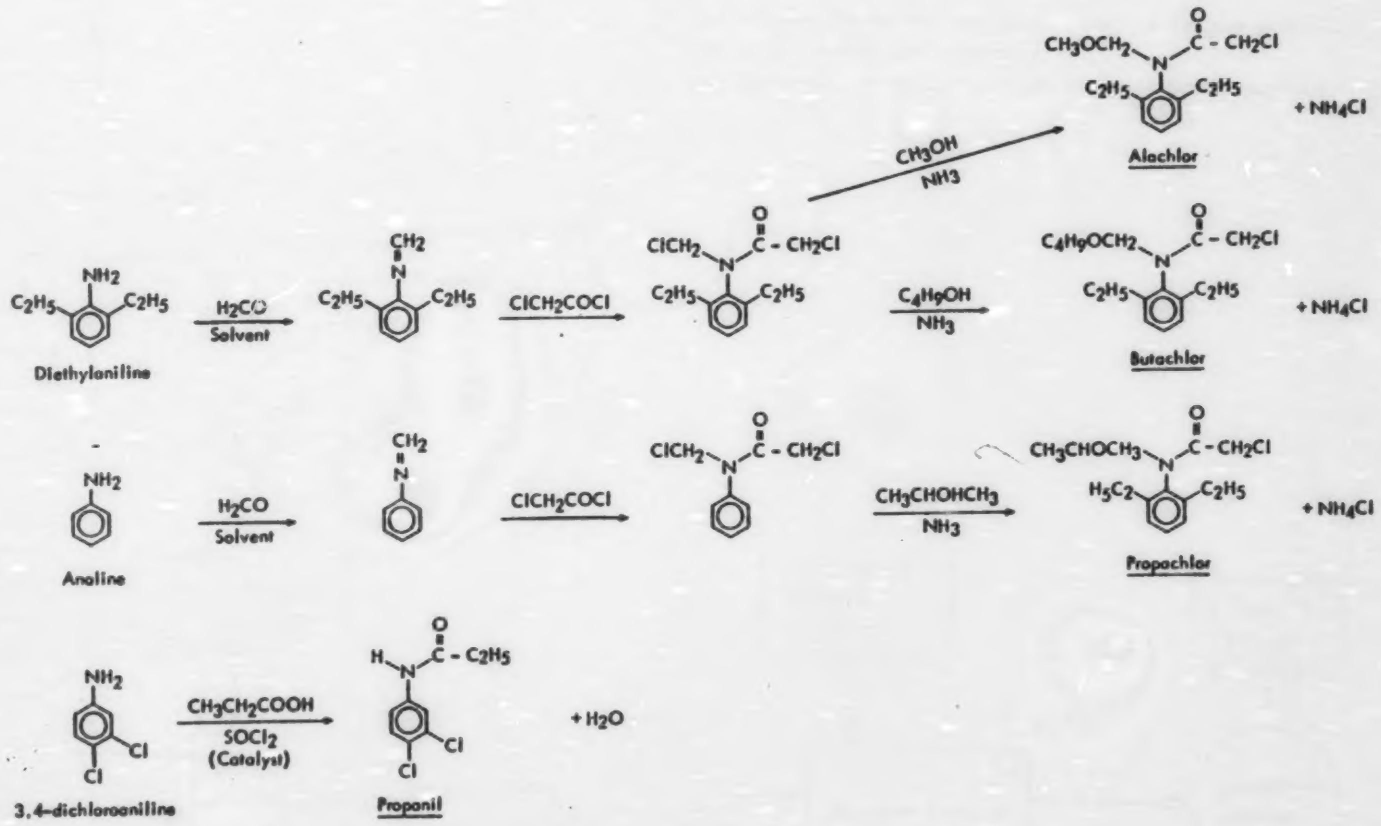
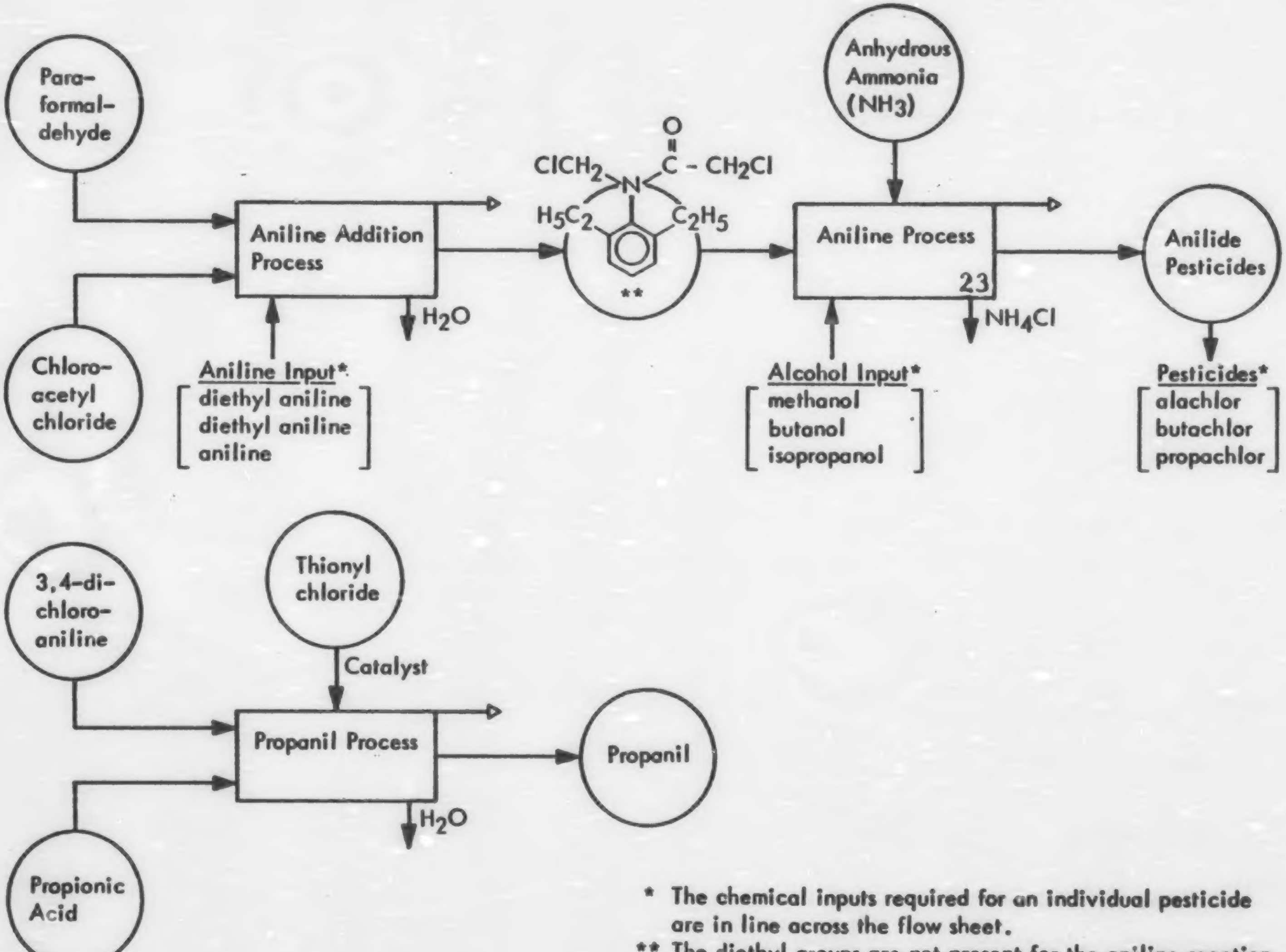

Diethylaniline
H2CO
Solvent
ClCH2COCl
CH3OH
NH3
Alachlor
+ NH4Cl
C4H9OH
NH3
Butachlor
+ NH4Cl
Anoline
H2CO
Solvent
ClCH2COCl
CH3CHOHCH3
NH3
Propachlor
+ NH4Cl
3,4-dichloroaniline
CH3CH2COOH
SOCl2
(Catalyst)
Propanil
+ H2O

Figure 17. Chemical reactions for production of anilide pesticides


Para-formaldehyde
Chloro-acetyl chloride
Aniline Addition Process
Aniline Input*
diethyl aniline
diethyl aniline
aniline
H_2O
$ClCH_2$
N
O
C - CH_2Cl
H_5C_2
C_2H_5
**
Anhydrous Ammonia (NH_3)
Aniline Process
23
NH_4Cl
Alcohol Input*
methanol
butanol
isopropanol
Anilide Pesticides
Pesticides*
alachlor
butachlor
propachlor
3,4-di-chloro-aniline
Thionyl chloride
Catalyst
Propanil Process
H_2O
Propanil
Propionic Acid

* The chemical inputs required for an individual pesticide are in line across the flow sheet.

** The diethyl groups are not present for the aniline reaction.

Figure 18. Flow sheet for anilide pesticide processes

Aniline Process, Alachlor

1. Function - Alachlor is produced by the reaction of diethyl(chloromethyl-chloroacetyl)anilide, anhydrous ammonia and methanol. The process involves a reaction step, production formulation, and waste handling.

   First, the ammonia and methanol are added to the anilide and solvent combination. The reaction products are alachlor and waste NH_4Cl. The alachlor is withdrawn and passed to either a liquid formulation or granule formulation unit. The waste NH_4Cl is combined with wastewaters and discharged with liquid effluent. The solvent is recovered and used as fuel.

2. Input Materials - Diethyl(chloromethyl-chloroacetyl)anilide, anhydrous ammonia, and methanol.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - The liquid effluent discharge contains H_2O and NH_4Cl.

6. EPA Source Classification Code - None exists.

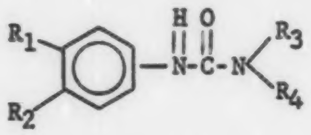
7. Reference -

   Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

Urea and Uracil Pesticides

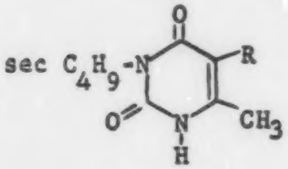
The urea and uracil pesticides include a group of about 25 pesticides used as herbicides. These pesticides can be synthesized from urea as a common base (as inferred by the classification). However, more frequently, they are synthesized from an isocyanate compound. Phosgene is used in the synthesis of most urea and uracil pesticides as indicated in the chemical reaction steps in Figure 19.

Most urea pesticides have the common chemical structure of:



with the R groups indicated in Table 7 for each pesticide. Other urea pesticides (noruron, isonoruron, cycluron and norea) have a similar structure with a replacement for the phenoxy ring.

The uracils have a common structure of the form:



where R is "-Br" for bromacil and "-Cl" for terbacil.

The production of urea and uracil pesticides in 1972 was estimated at 27 million pounds. Diuron was the most popular urea at 8 million pounds, followed by fluometuron at 4 million and linuron at 2 million pounds. Bromacil, a uracil pesticide, also had a production of 8 million pounds.

The process flow sheet for the production of urea and uracil pesticides is presented in Figure 20. The urea pesticides can be synthesized in a number of alternate reactions and eight possible reactions have been justified for monuron. The most likely processes and one alternate are indicated for monuron and diuron. The most likely process in current use is the reaction of phosgene with an aniline to form an isocyanate chemical (Isocyanate Process, Figure 20), which is then reacted with an aniline to form the urea pesticide (Amine Addition Process). Heat is added during the Isocyanate Process to release the second mole of HCl from the product and form the isocyanate. The production of the uracil pesticides is also indicated in Figure 20.

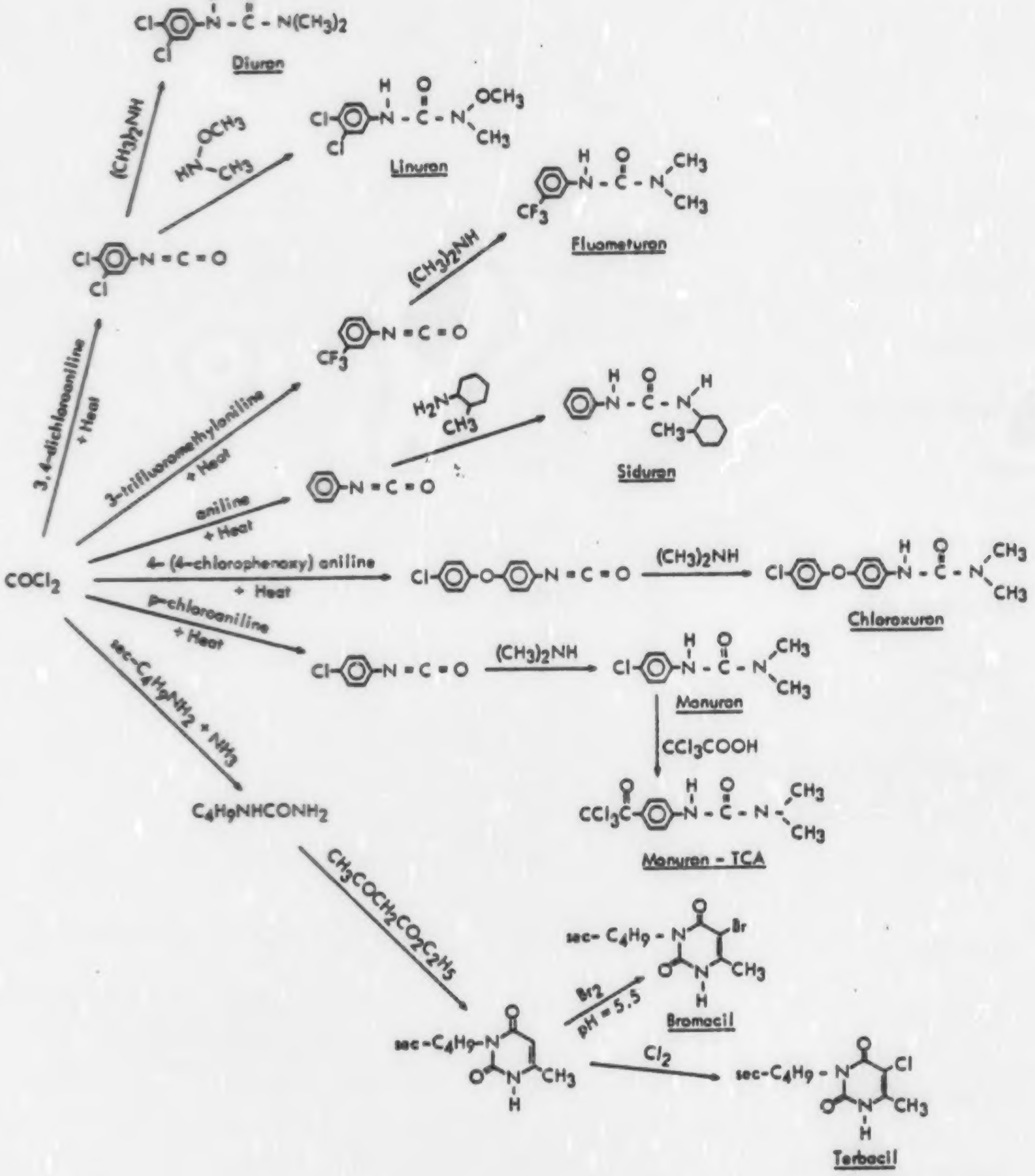
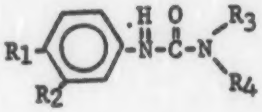

Diuron
Linuron
Fluometuron
Siduron
Chloroxuron
Monuron
Monuron - TCA
Bromacil
Terbacil
COCl2
3,4-dichloroaniline + Heat
3-trifluoromethylaniline + Heat
aniline + Heat
4-(4-chlorophenoxy) aniline + Heat
p-chloroaniline + Heat
sec-C4H9NH2 + NH3
C4H9NHCONH2
CH3COCH2CO2C2H5
(CH3)2NH
CCl3COOH
Br2
pH = 5.5
Cl2

Figure 19. Chemical reactions to form urea and uracil pesticides

Table 7. UREA PESTICIDES STRUCTURE



Pesticide	R_1	R_2	R_3	R_4
Chloroxuron	-4-chlorophenoxy	-H	$-CH_3$	$-CH_3$
Diuron	-Cl	-Cl	$-CH_3$	$-CH_3$
Fluometuron	-H	$-CF_3$	$-CH_3$	$-CH_3$
Linuron	-Cl	-Cl	$-OCH_3$	$-CH_3$
Monuron	-Cl	-H	$-CH_3$	$-CH_3$
Monuron-TCA	$-COOCl_3$	-H	$-CH_3$	$-CH_3$
Siduron	-H	-H	-H	-2-methycyclohexane
Other Area Pesticides: (less sales)				
Fenuron	-H	-H	$-CH_3$	$-CH_3$
Neburon	-Cl	-Cl	$-CH_3$	-n-butyl
Buturon	-Cl	-H	$-CH_3$	-1-butyn-3-yl
Monolinuron	-Cl	-H	$-OCH_3$	$-CH_3$
Metabromuron	-Br	-H	$-OCH_3$	$-CH_3$
Chlorobromuron	-Br	-Cl	$-OCH_3$	$-CH_3$
Metoxuron	$-OCH_3$	-Cl	$-CH_3$	$-CH_3$

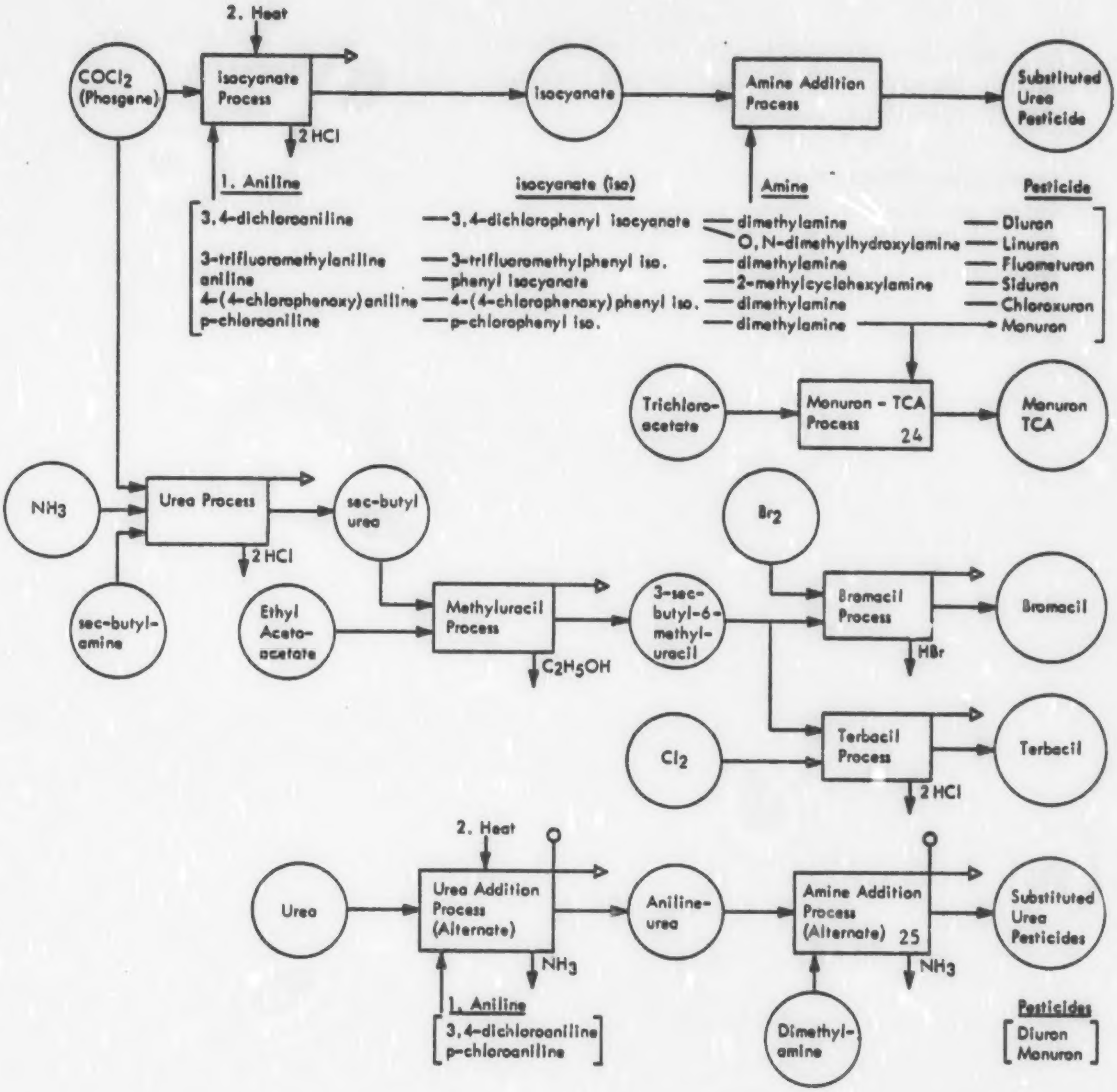

2. Heat
COCl2 (Phosgene)
Isocyanate Process
2 HCl
Isocyanate
Amine Addition Process
Substituted Urea Pesticide
1. Aniline
Isocyanate (iso)
Amine
Pesticide
3,4-dichloroaniline — 3,4-dichlorophenyl isocyanate — dimethylamine — Diuron
O,N-dimethylhydroxylamine — Linuron
3-trifluoromethylaniline — 3-trifluoromethylphenyl iso. — dimethylamine — Fluometuron
aniline — phenyl isocyanate — 2-methylcyclohexylamine — Siduron
4-(4-chlorophenoxy)aniline — 4-(4-chlorophenoxy)phenyl iso. — dimethylamine — Chloroxuron
p-chloroaniline — p-chlorophenyl iso. — dimethylamine — Monuron
Trichloro-acetate
Monuron - TCA Process
24
Monuron TCA
NH3
Urea Process
2 HCl
sec-butyl urea
sec-butyl-amine
Ethyl Aceto-acetate
Methyluracil Process
C2H5OH
3-sec-butyl-6-methyl-uracil
Br2
Bromacil Process
HBr
Bromacil
Cl2
Terbacil Process
2 HCl
Terbacil
2. Heat
Urea
Urea Addition Process (Alternate)
NH3
1. Aniline
3,4-dichloroaniline
p-chloroaniline
Aniline-urea
Amine Addition Process (Alternate)
25
NH3
Dimethyl-amine
Substituted Urea Pesticides
Pesticides
Diuron
Monuron

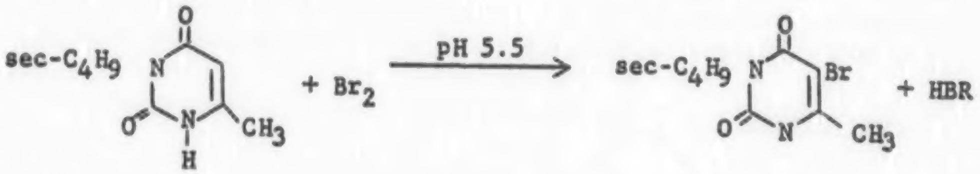
Figure 20. Flow sheet for urea and uracil pesticide processes

Data were not available for several processes within this industry segment. Therefore, detailed process descriptions were not prepared for the following processes:

Isocyanate Process
Amine Addition Process
Monuron-TCA Process
Methyluracil Process
Terbacil Process
Urea Addition Process

Bromacil Process

1. Function - Bromacil is produced by the reaction of 3-sec-butyl-6-methyl uracil and bromine. The 3-sec-butyl-6-methyl uracil for the process is produced using the Urea and Methyluracil Processes in the same plant. The bromacil process consists of the bromination of the uracil. The reaction chemistry is believed to be as follows:



The reaction step of the process consists of adding bromine and water to the uracil. NaOH is then added to the product to neutralize the solution. The product then goes through a filtration and drying step where the bromacil is obtained.

2. Input Materials - 3-Sec-butyl-6-methyl uracil and bromine.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - The NaBr waste stream is passed to a bromine recovery process.

6. EPA Source Classification Code - None exists.

7. Reference -

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Amine Addition Process, Diuron

1. Function - Diuron is produced by the reaction of 3,4-dichlorophenyl urea and dimethylamine. The 3,4-dichlorophenyl urea in solvent is mixed with the dimethylamine. The products of the reaction are waste NH_3 and crude diuron in solution. The product is then distilled to obtain the crude diuron. The solvent from the distillation is recycled to the process. The crude diuron is then dissolved in 30 to 35% HCl to remove impurities and then is precipitated with H_2O.

2. Input Materials - 3,4-Dichlorophenyl urea and dimethylamine.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - Aqueous waste contains some quantities of HCl.

6. EPA Source Classification Code - None exists.

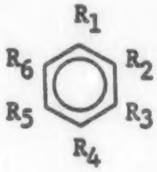
7. Reference -

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

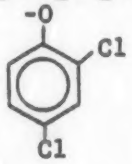
Nitrated Hydrocarbon Pesticides

The nitrated hydrocarbon pesticides include six pesticides with one or two of the characteristic nitro (-NO_2) groups in their chemical structure. These pesticides include the dinitroaromatics (trifluralin, benefin, dinoseb, and DNOC) and the chlorinated nitro hydrocarbons (nitrofen and chloropicrin). The dinitroaromatic pesticides and nitrofen are herbicides. Chloropicrin is an insecticide.

The general structure of the nitroaromatic pesticides is:



with the individual "R" groups indicated below.

Pesticide	R_1	R_2	R_3	R_4	R_5	R_6
Dinoseb	-OH	$-CH(CH_3)CH_2CH_3$	-H	$-NO_2$	-H	$-NO_2$
DNOC	-OH	$-CH_3$	-H	$-NO_2$	-H	$-NO_2$
Trifluralin	$-N(CH_2CH_2CH_3)_2$	$-NO_2$	-H	$-CF_3$	-H	$-NO_2$
Benefin	$-CH_3CH_2NCH_2CH_2CH_2CH_3$	$-NO_2$	-H	$-CF_3$	-H	$-NO_2$
Nitrofen		-H	-H	$-NO_2$	-H	-H

The estimated production of the nitrated hydrocarbon pesticides in 1972 was 33 million pounds. Trifluralin was the most popular herbicide in the group at 21 million pounds followed by dinoseb at 3 million pounds, and benefin at 2 million pounds. The production of chloropicrin, an insecticide, was about 5 million pounds.

The chemical reactions for the dinitroaromatic and other nitrated hydrocarbon pesticides are indicated in Figure 21. In addition, the process flow sheet is presented in Figure 22. The dinitroaromatic pesticides (all) incorporate the nitration process as shown in Figure 22. Trifluralin and benefin also include an additional amine addition process (Process 26 and 27. The input materials for nitrofen and chloropicrin are already

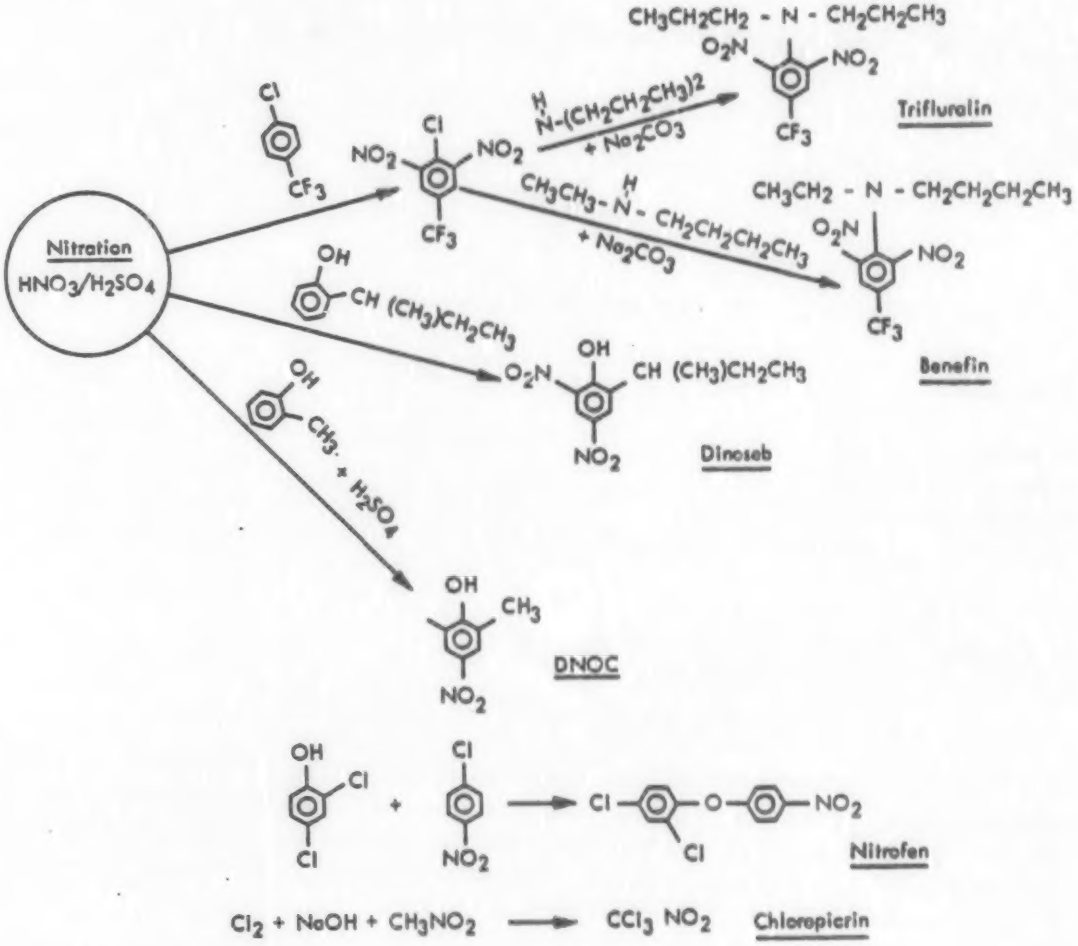
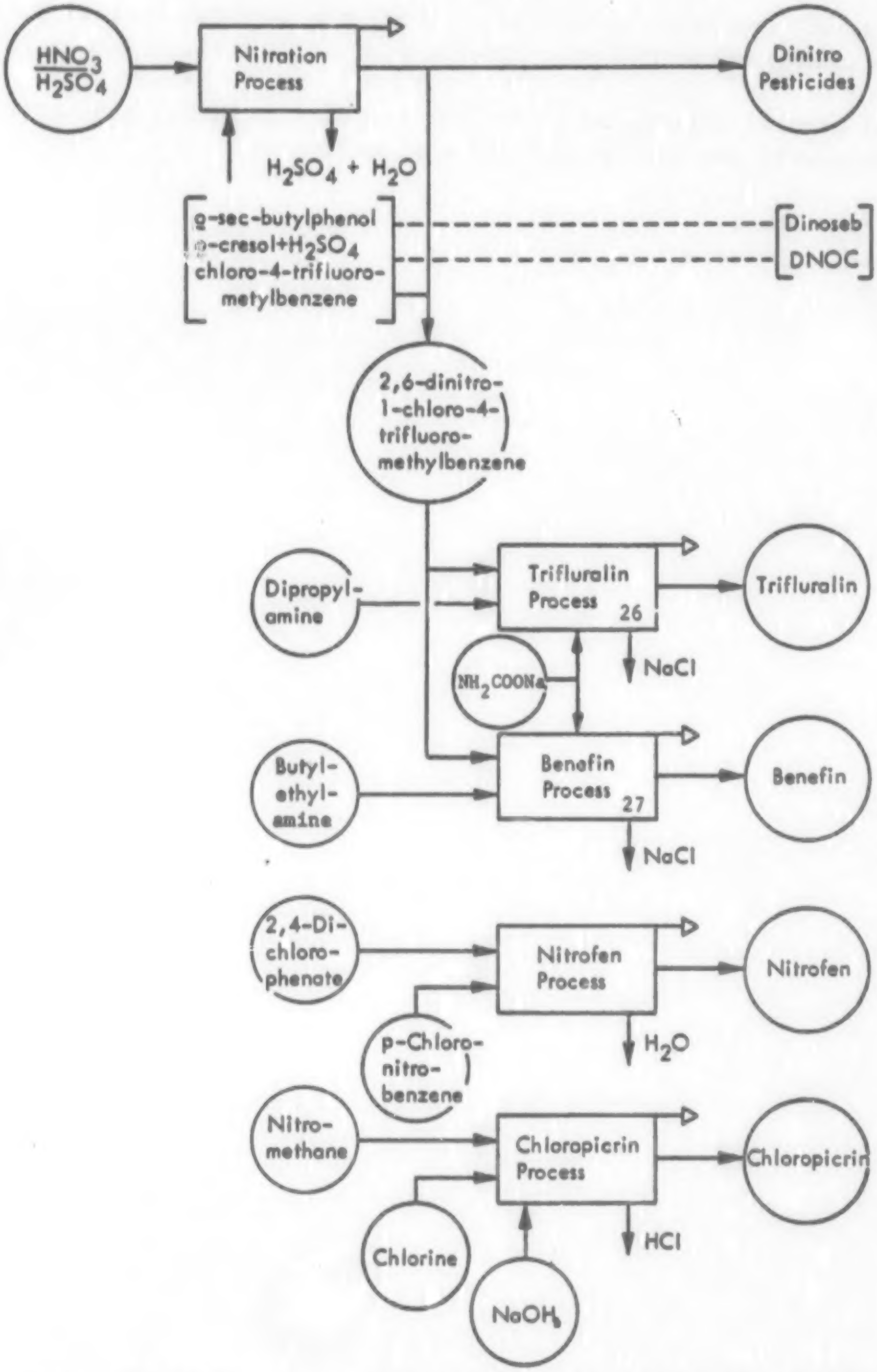

Nitration
HNO3/H2SO4
H N-(CH2CH2CH3)2 + Na2CO3
CH3CH3-N(H)-CH2CH2CH2CH3 + Na2CO3
CH3CH2CH2 - N - CH2CH2CH3
Trifluralin
CH3CH2 - N - CH2CH2CH2CH3
Benefin
CH (CH3)CH2CH3
Dinoseb
CH3 + H2SO4
DNOC
Nitrofen
Cl2 + NaOH + CH3NO2 → CCl3 NO2
Chloropicrin

Figure 21. Chemical reactions to produce the nitrated hydrocarbon pesticides



$\frac{HNO_3}{H_2SO_4}$
Nitration Process
Dinitro Pesticides
$H_2SO_4 + H_2O$
o-sec-butylphenol
o-cresol+H_2SO_4
chloro-4-trifluoro-metylbenzene
Dinoseb
DNOC
2,6-dinitro-1-chloro-4-trifluoro-methylbenzene
Dipropyl-amine
Trifluralin Process 26
Trifluralin
NH_2COONa
NaCl
Butyl-ethyl-amine
Benefin Process 27
Benefin
NaCl
2,4-Di-chloro-phenate
Nitrofen Process
Nitrofen
p-Chloro-nitro-benzene
H_2O
Nitro-methane
Chloropicrin Process
Chloropicrin
Chlorine
NaOH
HCl

Figure 22. Flow sheet for nitrated hydrocarbon pesticide processes

nitrated with one nitro group each. Thus, the nitrofen process is an addition reaction and the chloropicrin process is a chlorination reaction.

Detailed process descriptions were not prepared for those processes for which data were not available. Those processes are:

Nitration Process
Chloropicrin Process

NITRATED HYDROCARBON PESTICIDES PROCESS NO. 26

Trifluralin Process

1. Function - Trifluralin is produced by the reaction of 2,6-dinitro-1-chloro-4-trifluoromethylbenzene and dipropylamine with sodium carbamate. In some cases, the 2,6-dinitro-1-chloro-4-trifluoromethylbenzene is produced as shown in Figure 22 as a part of the same manufacturing process.

   The trifluralin process consists of the addition of sodium carbamate, dipropylamine, and water to the dinitro in $CHCl_3$ solvent. The products of the reaction are first filtered and then decanted to remove the saltwater waste. The crude trifluralin is then distilled in a vacuum still with aromatic naphtha and the resulting streams are technical grade trifluralin and $CHCl_3$. The $CHCl_3$ is recycled to the process.

2. Input Materials - Chloro-4-trifluoromethylbenzene and HNO_3/H_2SO_4 (or 2,6-dinitro-1-chloro-4-trifluoromethylbenzene) and dipropylene with sodium carbamate.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - The wastewaters contain NaCl.

6. EPA Source Classification Code - None exists.

7. References -

Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Benefin Process

1. Function - Benefin, a solid dinitroaniline, is produced by reaction of chloro-4-trifluoromethylbenzene, HNO_3/H_2SO_4 and butylethylamine. The nitration process is the same as for trifluralin. Since benefin and trifluralin are both made by Eli Lilly and Company, the nitrated product (chloro-4-trifluoromethyl-2,6-dinitrobenzene) is probably fed to both processes. Also, both final processes may use the same equipment by switching from dipropylamine to butylethylamine.

2. Input Materials - Chloro-4-trifluoromethylbenzene, HNO_3/H_2SO_4 and butylethylamine.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - The wastewaters contain NaCl.

6. EPA Source Classification Code - None exists.

7. References -

Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Other Nitrogenous Pesticides

This group of pesticides includes all pesticides containing nitrogen which have not been covered in the previous carbamate, triazine, anilide, urea, and nitrated hydrocarbon industrial segments. This group includes derivatives of imines, amines, cyanides, hydrazines, and guanidines. Fifteen pesticides with production exceeding 1 million pounds in 1972 are included in this group.

The estimated production in 1972 of other nitrogenous pesticides was 32 million pounds. The imide fungicides were the most popular with captan at 17 million pounds. CDAA, a preemergence herbicide, was next at 6 million pounds. Maleic hydrazide, a growth retardant, accounted for 4.5 million pounds.

The chemical reactions and structures of many of these nitrogenous pesticides are presented in Figure 23. The imide pesticides (captafol, captan and folpet) have a similar reaction of a sulphenyl chloride with an imide and NaOH. Many other nitrogenous pesticides also have a similar reaction between a chloride and an amine or other nitrogenous compound (as shown in Figure 23). No information is available for the reactions to produce methomyl and benomyl, which are both classified as amate pesticides.

The flow sheet for the imide and other nitrogenous pesticide processes is shown in Figures 24 and 25. The first two groups of imides and other pesticides have similar reaction processes with the inputs for each pesticide in line across the flow sheet.

Data for several of the processes within this industry segment were not available. These processes for which detailed process descriptions were not prepared include:

Cl Addition Process
Nitralin Process
Pichloram Process
Diphenamid Process
Dodine Process
Naphthalam Process
Methomyl Process
Benomyl Process

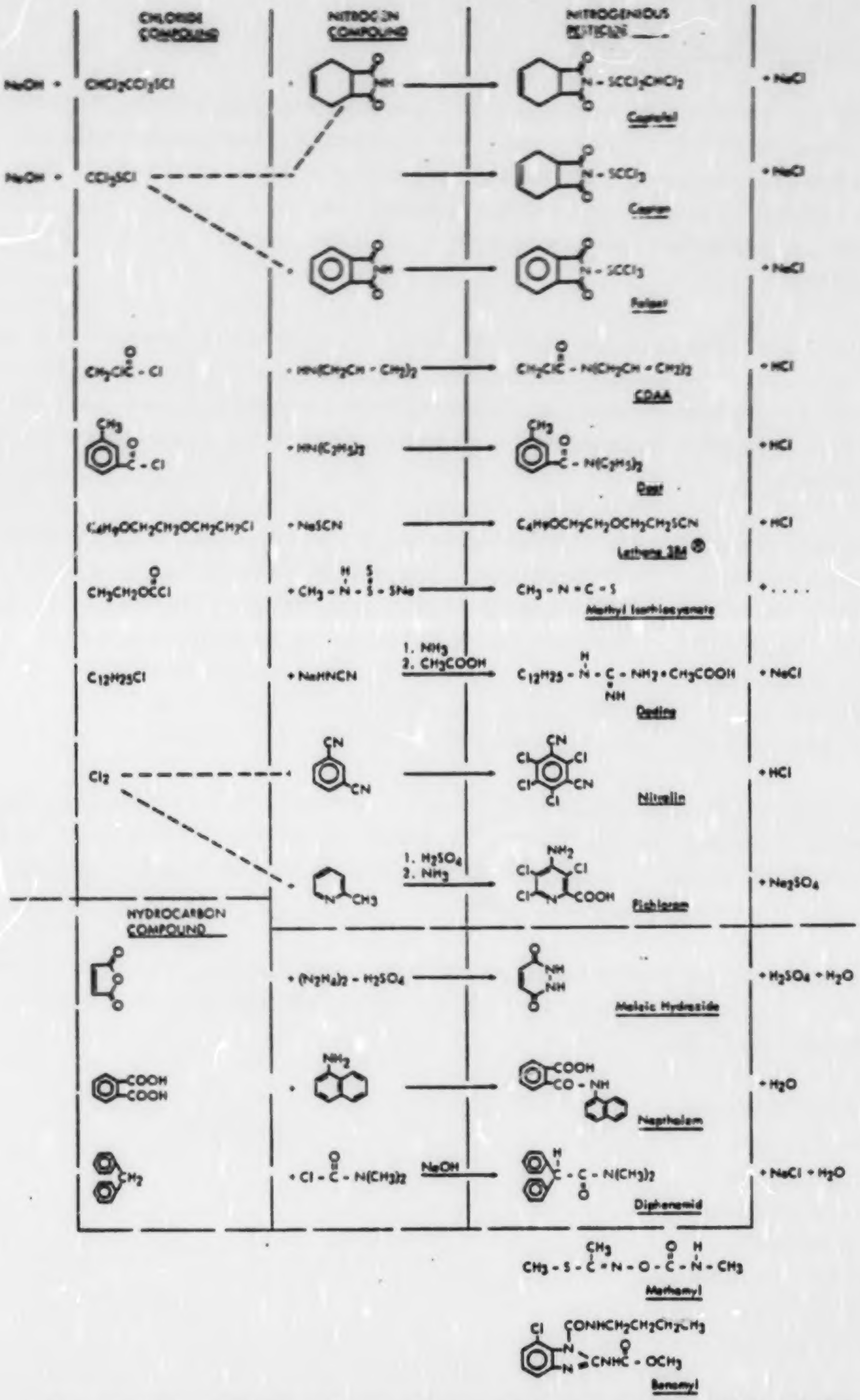
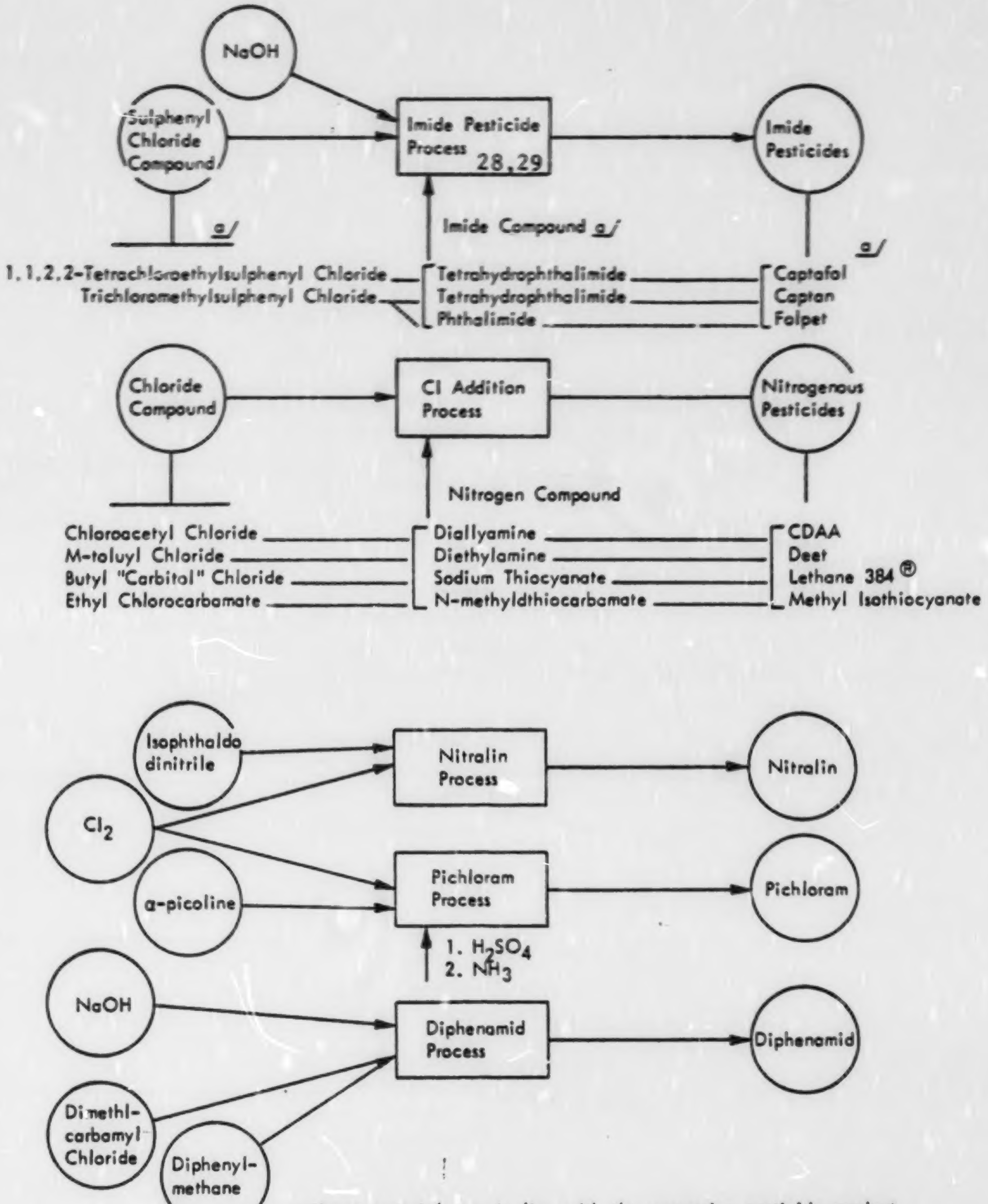

CHLORIDE COMPOUND
NITROGEN COMPOUND
NITROGENIOUS PESTICIDE
NaOH + CHCl2CCl2SCl
NaOH + CCl3SCl
N - SCCl2CHCl2
Captafol
N - SCCl3
Captan
N - SCCl3
Folpet
CH2ClC - Cl
+ HN(CH2CH = CH2)2
CH2ClC - N(CH2CH = CH2)2
CDAA
+ HN(C2H5)2
C - N(C2H5)2
Deet
C4H9OCH2CH2OCH2CH2Cl
+ NaSCN
C4H9OCH2CH2OCH2CH2SCN
Lethane 384 ®
CH3CH2OCCl
+ CH3 - N - S - SNa
CH3 - N = C = S
Methyl Isothiocyanate
C12H25Cl
+ NaHNCN
1. NH3
2. CH3COOH
C12H25 - N - C - NH2 • CH3COOH
Dodine
Cl2
Nitralin
1. H2SO4
2. NH3
COOH
Pichloram
HYDROCARBON COMPOUND
+ (N2H4)2 - H2SO4
Maleic Hydrazide
Naptalam
+ Cl - C - N(CH3)2
NaOH
C - N(CH3)2
Diphenamid
+ NaCl
+ HCl
+ . . . .
+ Na2SO4
+ H2SO4 + H2O
+ H2O
+ NaCl + H2O
CH3 - S - C = N - O - C - N - CH3
Methomyl
CONHCH2CH2CH2CH3
CNHC - OCH3
Benomyl

Figure 23. Chemical reactions and structures for imides, amides and other nitrogenous pesticides


NaOH
Sulphenyl Chloride Compound
Imide Pesticide Process 28,29
Imide Pesticides
a/
Imide Compound a/
a/
1,1,2,2-Tetrachloroethylsulphenyl Chloride
Trichloromethylsulphenyl Chloride
Tetrahydrophthalimide
Tetrahydrophthalimide
Phthalimide
Captafol
Captan
Folpet
Chloride Compound
Cl Addition Process
Nitrogenous Pesticides
Nitrogen Compound
Chloroacetyl Chloride
M-toluyl Chloride
Butyl "Carbitol" Chloride
Ethyl Chlorocarbamate
Diallyamine
Diethylamine
Sodium Thiocyanate
N-methyldthiocarbamate
CDAA
Deet
Lethane 384 ®
Methyl Isothiocyanate
Isophthalda dinitrile
Nitralin Process
Nitralin
Cl2
a-picoline
Pichloram Process
Pichloram
1. H2SO4
2. NH3
NaOH
Diphenamid Process
Diphenamid
Dimethl-carbamyl Chloride
Diphenyl-methane

a/ Input materials are in line with the respective pesticide product.

Figure 24. Flow sheet for imides and other nitrogenous pesticide processes

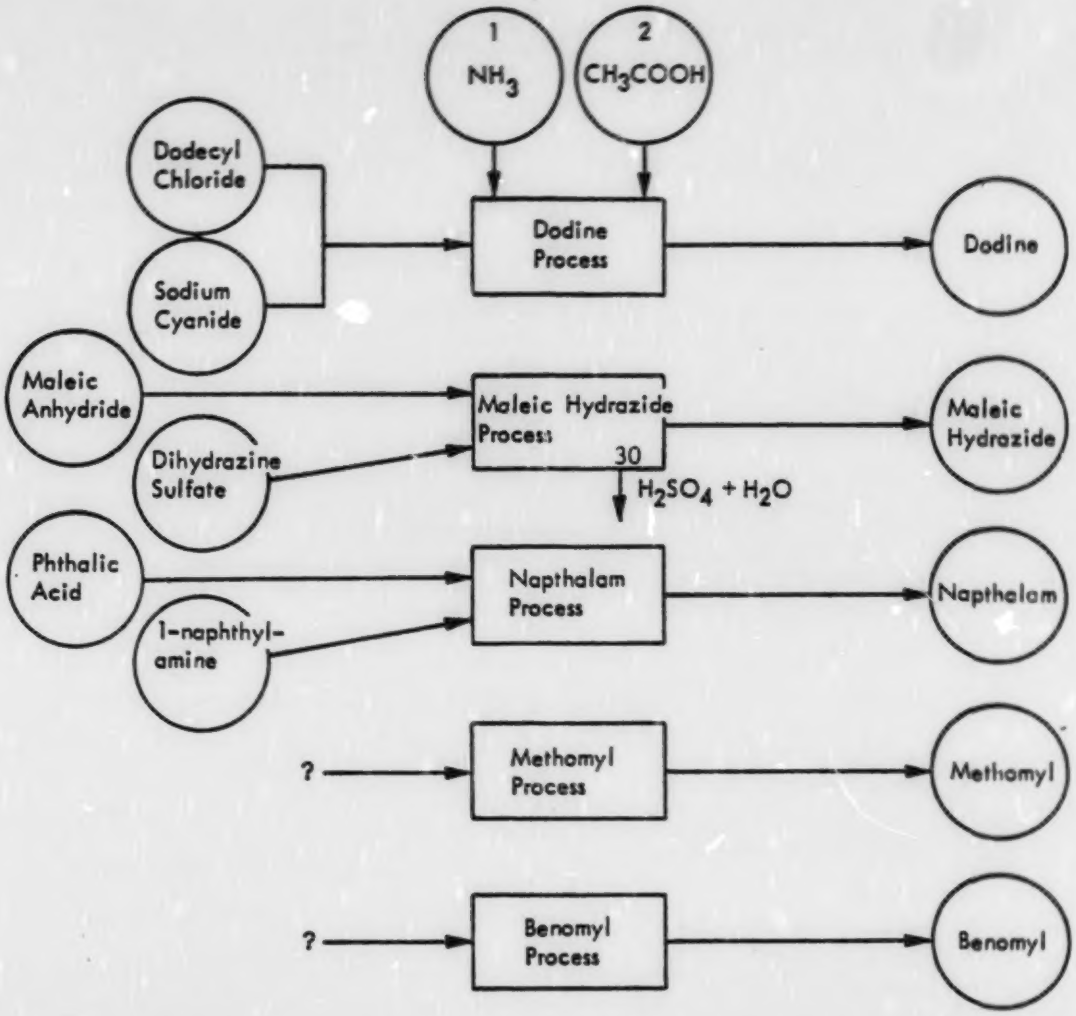

1
NH_3
2
CH_3COOH
Dodecyl Chloride
Sodium Cyanide
Dodine Process
Dodine
Maleic Anhydride
Dihydrazine Sulfate
Maleic Hydrazide Process
30
$H_2SO_4 + H_2O$
Maleic Hydrazide
Phthalic Acid
1-naphthyl-amine
Napthalam Process
Napthalam
?
Methomyl Process
Methomyl
?
Benomyl Process
Benomyl

Figure 25. Flow sheet for other nitrogenous pesticide processes

PROCESS NO. 28

Imide Pesticide Process, Captan

1. **Function** - Captan is produced by the reaction of sodium hydroxide, trichloromethylsulphenyl chloride (perchloromethyl mercaptan (PMM)), and tetrahydrophthalimide (THPI). Both PMM and THPI are manufactured on site.

   Captan is produced in a two-step reaction process followed by several purification steps. The first reaction step is simply the dissolving of PMM in NaOH to form the sodium salt of PMM and water. The second reaction step combines this salt and THPI to form captan and NaCl. The captan is then purified and packaged.

2. **Input Materials** - Sodium hydroxide, trichloromethylsulphenyl chloride, and tetrahydrophthalimide.

3. **Operating Parameters** - Second reaction step:
   - Temperature: 10 to 30°C.
   - Pressure: Atmospheric.
   - Reaction time: 10 to 40 min.
   - Solution: Aqueous medium of pH 10.0 to 10.5.

4. **Utilities** - Data not available.

5. **Waste Streams** -

Process Wastes and Losses at One Plant

Material	Form	Amount produced (lb/lb AI)	Disposition
Active ingredient	Particulates	~ 4 lb/day	
Solvents			
Liquid		10 tons/year	Asphalt-lined settling pond; discharge
Solid paper		10 tons/year	Local collector
Metal		25 tons/year	Local scrap dealers
Miscellaneous chemicals		1,200 lb/year	Buried on plant property

6. **EPA Source Classification Code** - None exists.

7. References -

Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Sittig, M., Pesticide Production Processes 1967, Noyes Development Corporation (1967).

California Spray-Chemical Corporation, The Chemistry of Captan, 31 March 1955.

Imide Pesticide Process, Folpet

1. Function - Folpet is made by reaction of sodium hydroxide, trichloromethylsulphenyl chloride, and phthalimide. Folpet is made by Calhio Corporation at Perry, Ohio, in the same facility which produces captan and with the same trichloromethylsulphenyl chloride (perchloromethyl mercaptan) intermediate chemical.

   The steps for producing the trichloromethylsulphenyl chloride are the same as in the production of captan. The phthalimide is produced by an amination reaction similar to that used in captan production.

2. Input Materials - Sodium hydroxide, trichloromethylsulphenyl chloride and phthalimide.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - Similar to captan (see preceding process sheet).

6. EPA Source Classification Code - None exists.

7. References -

Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Sittig, M., Pesticide Production Processes 1967, Noyes Development Corporation (1967).

Maleic Hydrazide Process

1. Function - Maleic anhydride and dihydrazine sulfate are combined to yield maleic hydrazide, a solid hydrazide pesticide.

2. Input Materials - Maleic anhydride and dihydrazine sulfate.

3. Operating Parameters - Temperature: 75 to 110°C (exothermic reaction).
   - Reaction time: About 3-1/2 hr with stirring.
   - Product recovery: Batch cooled to 25°C. Product recovered by vacuum filtration, then washed free of sulfate and dried.

4. Utilities - Data not available.

5. Waste Streams - H_2SO_4 is a by-product.

6. EPA Source Classification Code - None exists.

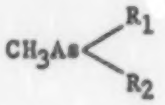
7. Reference -

Sittig, M., Pesticide Production Processes 1967, Noyes Development Corporation (1967).

Organoarsenic and Organometallic Pesticides

The organoarsenical and organometallic pesticides are a small group of about 15 pesticides. The organoarsenical pesticides are herbicides, and the organometallic pesticides are predominantly mercury and copper fungicides.

The organoarsenic pesticides are all derived from sodium arsenite. DSMA, the derivative, is also the intermediate chemical for producing MSMA, methane arsenic acid and cacodylic acid as indicated in Figure 26. The structure of the organoarsenic pesticides is:



Pesticide	R_1	R_2
DSMA	-ONa	-ONa
MSMA	-ONa	-OH
MAA	-OH	-OH
Cacodylic acid	$-CH_3$	-OH

The main two organomercuric pesticides are formed with benzene from mercuric acetate and mercuric oleate to form PMA and phenyl mercuric oleate. The major organocopper pesticide is formed by reacting naphthenic acids with soluble copper salts to form copper naphthenates.

The estimated production in 1972 of organoarsenic pesticides was 32.7 million pounds. MSMA and MAA accounted for 24 million pounds of the total. The combined organomercuric production was less than 1 million pounds. The copper naphthenates were the leading organometallic pesticide at 2.2 million pounds. Based on the Tariff Commission data, the production of organoarsenic pesticides increased from 32.7 to 42.1 million pounds from 1972 to 1973. The production has increased significantly for each year from 1971 through 1973.

The chemical reactions for all of these pesticides are indicated in Figure 26. Also, the flow sheet for organoarsenic and organometallic pesticide processes is shown in Figure 27.

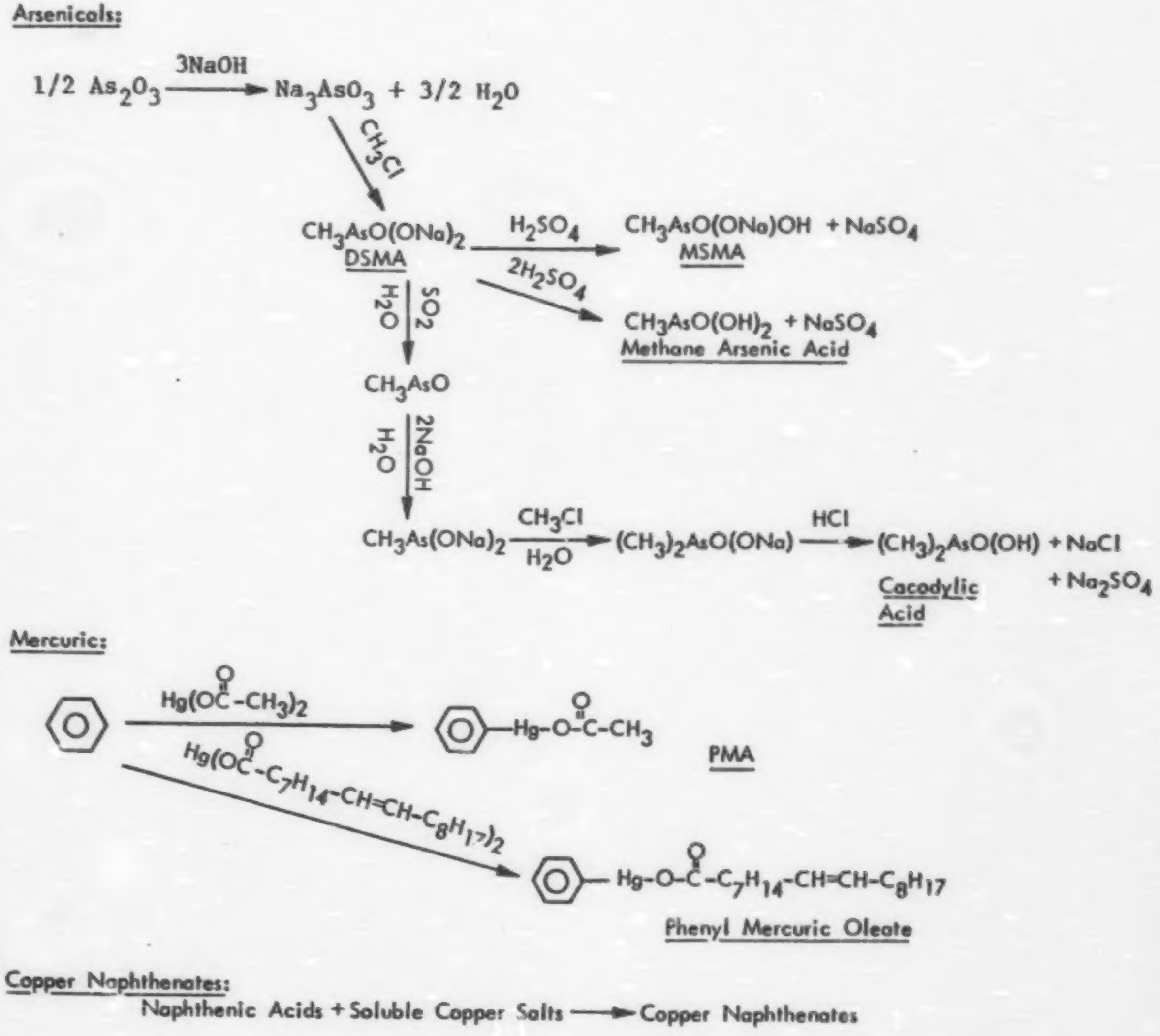

Arsenicals:
1/2 As_2O_3 $\xrightarrow{3NaOH}$ Na_3AsO_3 + 3/2 H_2O
CH_3Cl
$CH_3AsO(ONa)_2$
DSMA
H_2SO_4
$CH_3AsO(ONa)OH$ + $NaSO_4$
MSMA
$2H_2SO_4$
$CH_3AsO(OH)_2$ + $NaSO_4$
Methane Arsenic Acid
SO_2
H_2O
CH_3AsO
2NaOH
H_2O
$CH_3As(ONa)_2$
CH_3Cl
H_2O
$(CH_3)_2AsO(ONa)$
HCl
$(CH_3)_2AsO(OH)$ + NaCl
+ Na_2SO_4
Cacodylic Acid
Mercuric:
$Hg(O\overset{O}{C}-CH_3)_2$
$Hg-O-\overset{O}{C}-CH_3$
PMA
$Hg(O\overset{O}{C}-C_7H_{14}-CH=CH-C_8H_{17})_2$
$Hg-O-\overset{O}{C}-C_7H_{14}-CH=CH-C_8H_{17}$
Phenyl Mercuric Oleate
Copper Naphthenates:
Naphthenic Acids + Soluble Copper Salts → Copper Naphthenates

Figure 26. Chemical reactions to produce organoarsenic and organometallic pesticides

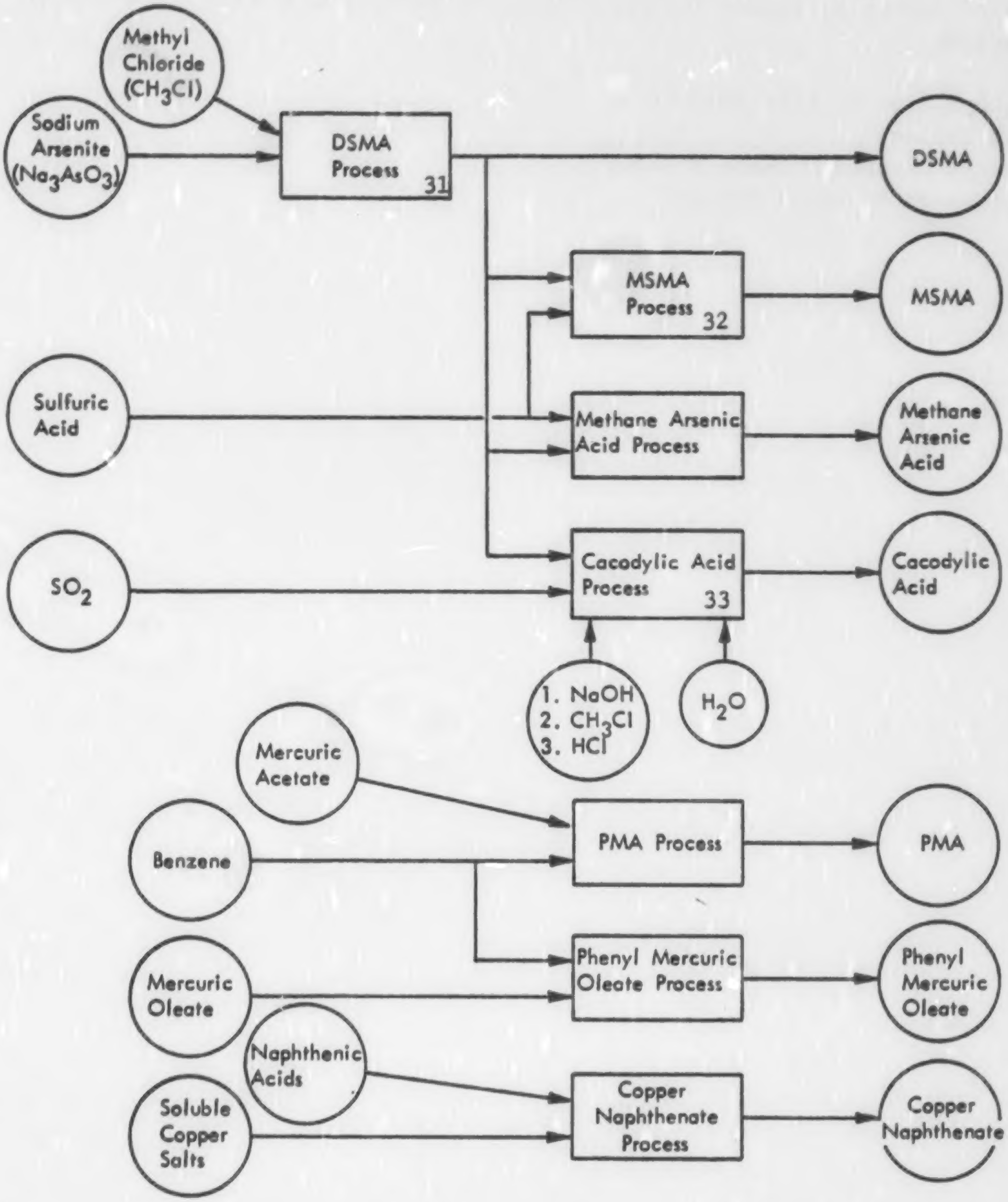

Methyl Chloride (CH_3Cl)
Sodium Arsenite (Na_3AsO_3)
DSMA Process 31
DSMA
MSMA Process 32
MSMA
Sulfuric Acid
Methane Arsenic Acid Process
Methane Arsenic Acid
SO2
Cacodylic Acid Process 33
Cacodylic Acid
1. NaOH 2. CH3Cl 3. HCl
H2O
Mercuric Acetate
Benzene
PMA Process
PMA
Mercuric Oleate
Phenyl Mercuric Oleate Process
Phenyl Mercuric Oleate
Naphthenic Acids
Soluble Copper Salts
Copper Naphthenate Process
Copper Naphthenate

Figure 27. Flow sheet for organoarsenic and organometallic pesticide processes

Data for some of the processes in this industry segment were not available. These processes for which detailed descriptions were not prepared include:

Methyl Arsenic Acid Process
PMA Process
Phenyl Mercuric Oleate Process
Copper Naphthenate Process

DSMA Process

1. Function - DSMA is produced by the reaction of arsenic trioxide, sodium hydroxide, and methyl chloride. The process includes a two-stage reaction, precipitation and filtration. The reaction chemistry is as follows:

$$As_2O_3 + 6NaOH \longrightarrow 2Na_3AsO_3 + 3H_2O \qquad (1)$$

$$Na_3AsO_3 + CH_3Cl \longrightarrow \underset{\text{(DSMA)}}{CH_3AsO(ONa)_2} + NaCl \qquad (2)$$

In practice, the reaction in Eq. (1) is not initially allowed to go to completion. A sodium to arsenic ratio of less than 3:1 is used initially with the balance of the NaOH being added in proportion to the addition of methyl chloride. An excess of CH_3Cl is used in order to assure a virtually complete conversion of the sodium arsenite.

Following the addition of all reactants, the contents are allowed to "digest" until the reaction ceases. The contents are then cooled and the DSMA is precipitated by the addition of a suitable liquid such as isopropyl alcohol.

2. Input Materials - Arsenic trioxide, sodium hydroxide, and methyl chloride.

3. Operating Parameters - Reaction (2) temperature: 60 to 90°C.
   - Reaction (2) pressure: 60 to 120 psig.
   - Pressure after "digestion": 5 to 10 psig.

4. Utilities - Data not available.

5. Waste Streams - NaCl appears as a waste product of the methylarsenic unit but no data are available as to the disposition of the waste.

6. EPA Source Classification Code - None exists.

7. Reference -

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

MSMA Process

1. Function - MSMA is produced by the reaction of DSMA and sulfuric acid. To obtain MSMA, crude DSMA is combined in a single-stage reaction with H_2SO_4. The products are then passed through an evaporation step where aqueous CH_3OH is removed. The remaining product is then centrifuged to obtain 58% MSMA and by-product salts.

2. Input Materials - DSMA and sulfuric acid.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - Discharge at one plant to two equalization ponds contains 0.7 to 0.8 ppm arsenic as well as NaCl and Na_2SO_4. The by-product salts, Na_2SO_4 and NaCl, are a disposal problem because they contain arsenic. One manufacturer washes the salts in a five-stage countercurrent washing cycle and then disposes of them in an approved dump.

6. EPA Source Classification Code - None exists.

7. Reference -

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Cacodylic Acid Process

1. Function - Cacodylic acid, a solid organoarsenic pesticide, is produced by reaction of DSMA (or the equivalent input materials), sulfur dioxide, and methyl chloride.

2. Input Materials - DSMA, sulfur dioxide, and methyl chloride.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - At one plant all the liquid streams are recycled for reuse. A number of multiple effect evaporators are employed in the solution recycling systems. The process does, however, create a solid waste which is a mixture of sodium chloride and sodium sulfate containing 1 to 1-1/2% cacodylate contaminants.

6. EPA Source Classification Code - None exists.

7. References -

Ottinger, R. S., J. L. Blumenthal, D. F. Dal Porto, G. I. Gruber, M. J. Santy, and C. C. Shih, TRW Systems Group, Recommended Methods of Reduction, Neutralization, Recovery of Disposal of Hazardous Waste, Volume VI, U.S. Environmental Protection Agency, Contract No. 68-03-0089, Washington, D.C., August 1973.

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Microbial and Natural-Occurring Pesticides

Two types of microorganisms pathogenic to insects have been developed and are in limited commercial use on several crops today, i.e., preparations of *Bacillus* species, and nuclear polyhedrosis viruses.

Several commercial products based upon *Bacillus thuringiensis* are currently available on the U.S. market. These products are exempted from the requirement of a tolerance and are registered for the control of lepidopterous insects on a considerable number of crops. The main deterrent to their use is that growers are familiar with the chemical insecticides and their more rapid mode of action, and chemical insecticides are often less expensive per unit control. Preparations based on *Bacillus popilliae* and several other *Bacillus* species are under commercial development, but have not yet reached the volume of use of *Bacillus thuringiensis*.

Several nuclear polyhedrosis virus preparations are available in the U.S. for control of cotton bollworms, *Heliothis* spp. These products are not widely used at this time. Problems concerning their large-scale production, formulation, storage stability, application timing and methods, stability after application, and safety precautions remain to be resolved. Development work is in process on a number of other insect viruses, including those of the cabbage looper, *Trichoplusia ni*; the alfalfa looper, *Autographa californica*; the Douglas fir tussock moth, *Hemerocampa pseudotsugata*; and several others.

Bacillus preparations are of interest to growers, especially for the control of lepidopterous insects on lettuce and cole crops close to harvest when there may be restrictions on the use of chemical insecticides. So far as application timing and technique is concerned, *Bacillus* preparations can be used as direct substitutes for chemical insecticides for the uses for which they are registered, or even combined with chemicals in the spray tank. On the other hand, the virus preparations known to date do not work well if they are used in the same manner as chemical insecticides. They normally work best as components of complete integrated pest management systems.

Microbial pathogens useful for the nonchemical control of weeds or plant diseases have not been commercially developed to this date.

Natural-occurring pesticides include the pyrethrins and obtusaquinone. The pyrethrins are derived from the chrysanthemum flower, and obtusaquinone is an orange pigment of the tropical cocobolo tree. Pyrethrin pesticides have also been synthesized and some of these offer promise as insect-specific insecticides.

The processes for production of the microbial and natural-occurring pesticides are at present considerably different from the chemical reactions for other pesticides. The microbial pesticides are developed from cultures in fermented solutions as expressed by the following procedure for *Bacillus thuringiensis*:

$$\text{Nutrient mixture} \xrightarrow{\text{Sterilize}} \xrightarrow{\text{Innoculate}} \xrightarrow{\text{Ferment}} \xrightarrow{\text{Separate}} \xrightarrow{\text{Dry}} \text{Product solid containing} \sim 3\%\ \text{B.t.}$$

The pyrethrins are extracted from chrysanthemum flowers as follows:

$$\text{Chrysanthemum flowers } (\underline{\text{Pyrethrum cineraefolium}}) \xrightarrow{\text{Solvent}} \text{Crude Extract} \xrightarrow[\text{Excract with}]{CH_3OH} \xrightarrow[\text{Extract with}]{C_6H_{14}} \text{Pyrethrin concentrate}$$

The most popular microbial pesticide is *Bacillus thuringiensis* with an estimated production of 1 million pounds in 1972. The total production of microbial and natural-occurring pesticides was about 2 million pounds in 1972. The use of these pesticides is expected to increase significantly in the next decade as new and more effective derivatives are formed and as some of the more toxic and persistant chemical pesticides are forced out by environmental restrictions.

The input materials for *Bacillus thuringiensis* and pyrethrin and the processes are indicated in Figure 28. Additional details are presented in the process description sheets.

The reaction and production processes for *Bacillus thuringiensis* and the pyrethrins are described in the following process description sheets (Processes 34 and 35). Other microbial and natural-occurring pesticide processes are not included since production volumes are low and the process data are not available.

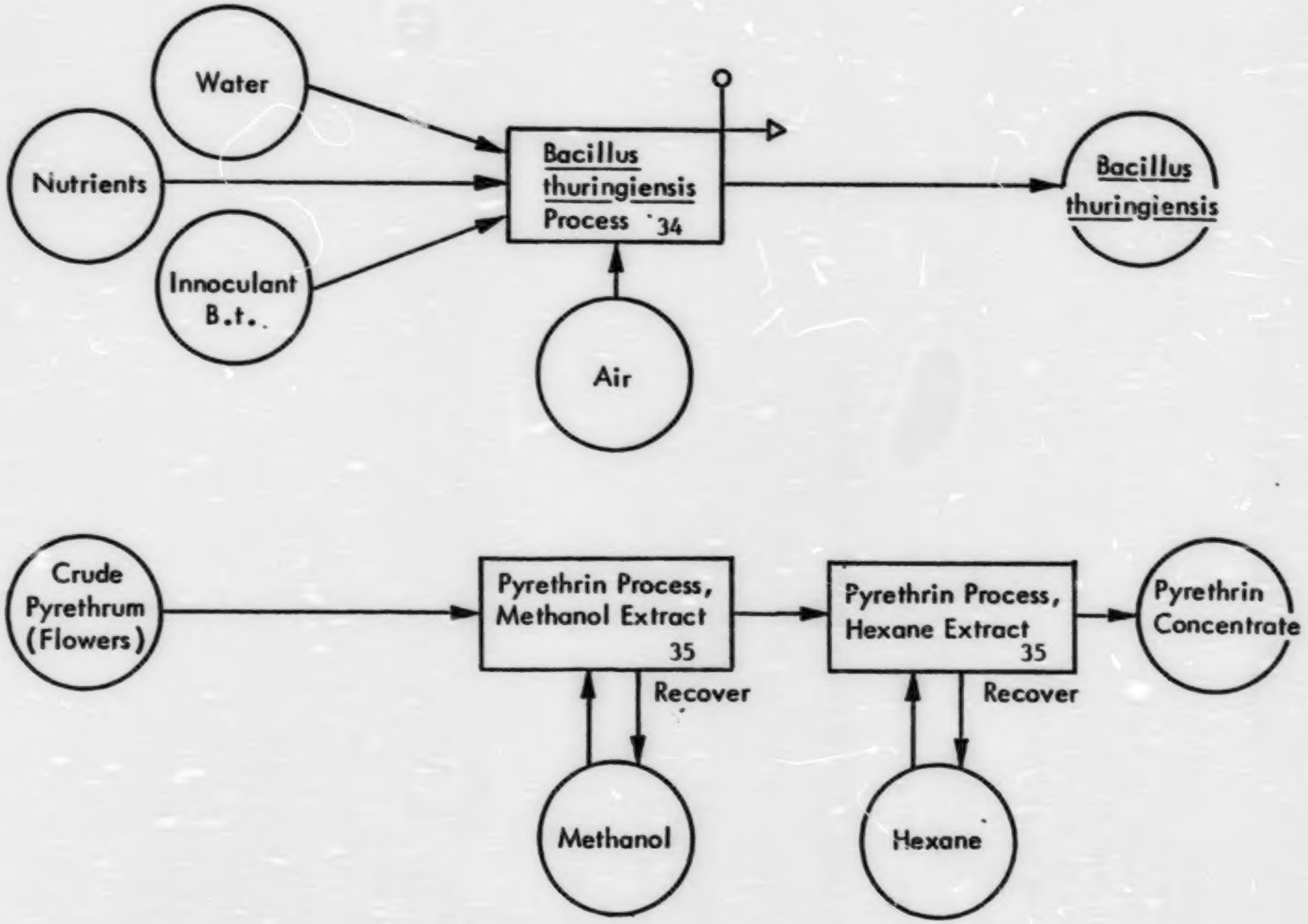

Water
Nutrients
Innoculant B.t..
Bacillus thuringiensis Process 34
Air
Bacillus thuringiensis
Crude Pyrethrum (Flowers)
Pyrethrin Process, Methanol Extract 35
Recover
Methanol
Pyrethrin Process, Hexane Extract 35
Recover
Hexane
Pyrethrin Concentrate

Figure 28. Flow sheet for microbial and natural-occurring pesticide processes

Bacillus thuringiensis Process

1. Function - Bacillus thuringiensis (B.t.) is produced via a fermentation process. The input materials identified below are added to a fermentation tank containing water and innoculant B.t. After fermentation the material containing B.t. is withdrawn and centrifuged to separate the solids. These solids are then dried and milled to obtain a solid containing 3% B.t.

2. Input Materials - Soybean meal, corn steep liquor, minerals, water, and innoculant B.t. (alternate process: wheat bran, casein, molasses, vitamins, water and innoculant B.t.).

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - The liquid wastes from the fermentation tank are either passed to an evaporation pond or are sterilized with heat, treated and discharged to a lake.

6. EPA Source Classification Code - None exists.

7. Reference -

Lawless, E. W., T. L. Ferguson, and R. von Rümker, Pollution Potential in Pesticide Manufacture, Final Report, by Midwest Research Institute on Contract No. 68-01-0142 for the Environmental Protection Agency, June 1972.

Pyrethrin Process

1. Function - The pyrethrins, derivatives of the chrysanthemum flower, are produced by an extraction process using methanol and hexane. The process incorporates two extraction steps, a dewaxing extraction and a deresining extraction.

   First, the methanol and crude pyrethrin are mixed. The wax residue is recovered as a by-product. The methanol extract is filtered with charcoal and then stripped and distilled. The distillation yields methanol and semi-finished pyrethrin. The methanol is recycled to the process and the pyrethrin is combined with the hexane. The resin from this step is recovered as a product. The hexane extract is filtered with ionol and celite and then stripped. The stripping yields hexane which is recycled and pyrethrin concentrate. The concentrate is then diluted in kerosene to obtain 20% pyrethrin.

2. Input Materials - Crude pyrethrin and make-up amounts of methanol and hexane.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - Data not available.

6. EPA Source Classification Code - None exists.

7. Reference -

   Lawless, E. W., T. L. Ferguson, and R. von Rümker, Pollution Potential in Pesticide Manufacturing, Final Report, by Midwest Research Institute on Contract No. 68-01-0142 for the Environmental Protection Agency, June 1972.

Other Pesticides

Organic pesticides which did not fit well in other operations include methyl bromide, endothall, bensulide and EXD. These four pesticides are discussed in this industry segment. Some other organic pesticides may have been omitted because of low volumes of production (100,000 lb/year or less). Other large-volume pesticides such as elemental sulfur, sodium chlorate, and the organotin compounds were excluded because these materials are products of other industries and are predominantly used for other purposes. Creosote has also been excluded since it is a natural product from coking operations at foundries. (Note that creosote is the number one pesticide with about 1 billion pounds used in 1972 as a wood preservative for fence posts, railroad ties and telephone poles.)

Methyl bromide is the most popular of these "other" pesticides with an estimated production in 1972 of 25 million pounds. The other pesticides also include endothall at 2 million pounds, bensulide at 1 million pounds and EXD at 0.5 million pounds.

The chemical reactions and structures of the four pesticides (methyl bromide, endothall, bensulide and EXD) are presented in Figure 29. As can be seen, none of the reactions or structures are similar. The process flow sheet is presented in Figure 30.

Data for some of the processes in this industry segment were not available. These processes for which detailed process descriptions were not prepared include:

Bensulide Process
EXD Process

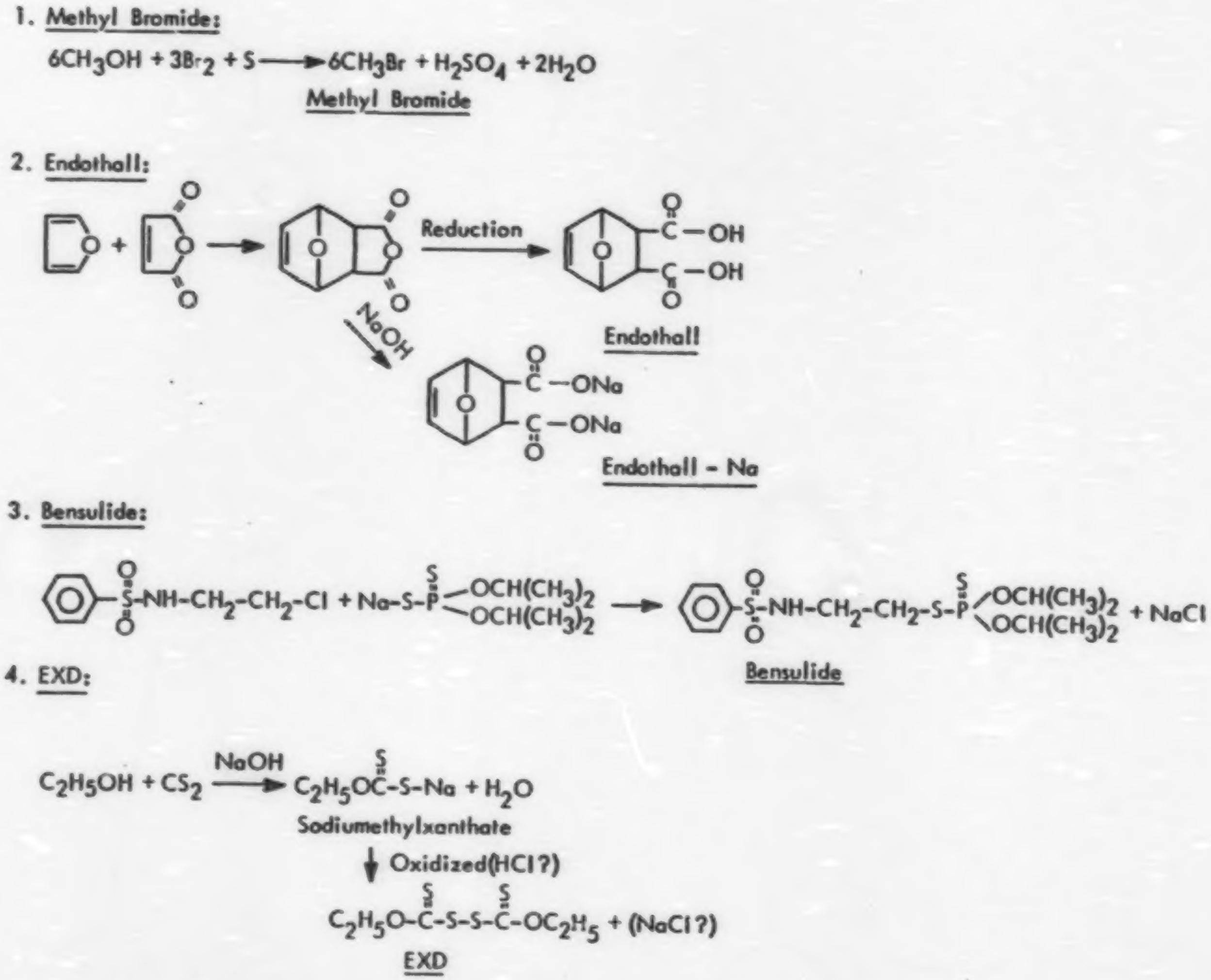

1. Methyl Bromide:
6CH3OH + 3Br2 + S → 6CH3Br + H2SO4 + 2H2O
Methyl Bromide
2. Endothall:
Reduction
NaOH
Endothall
Endothall - Na
3. Bensulide:
Bensulide
+ NaCl
4. EXD:
NaOH
Sodiumethylxanthate
Oxidized(HCl?)
+ (NaCl?)
EXD

Figure 29. Other pesticides chemical reactions and structures

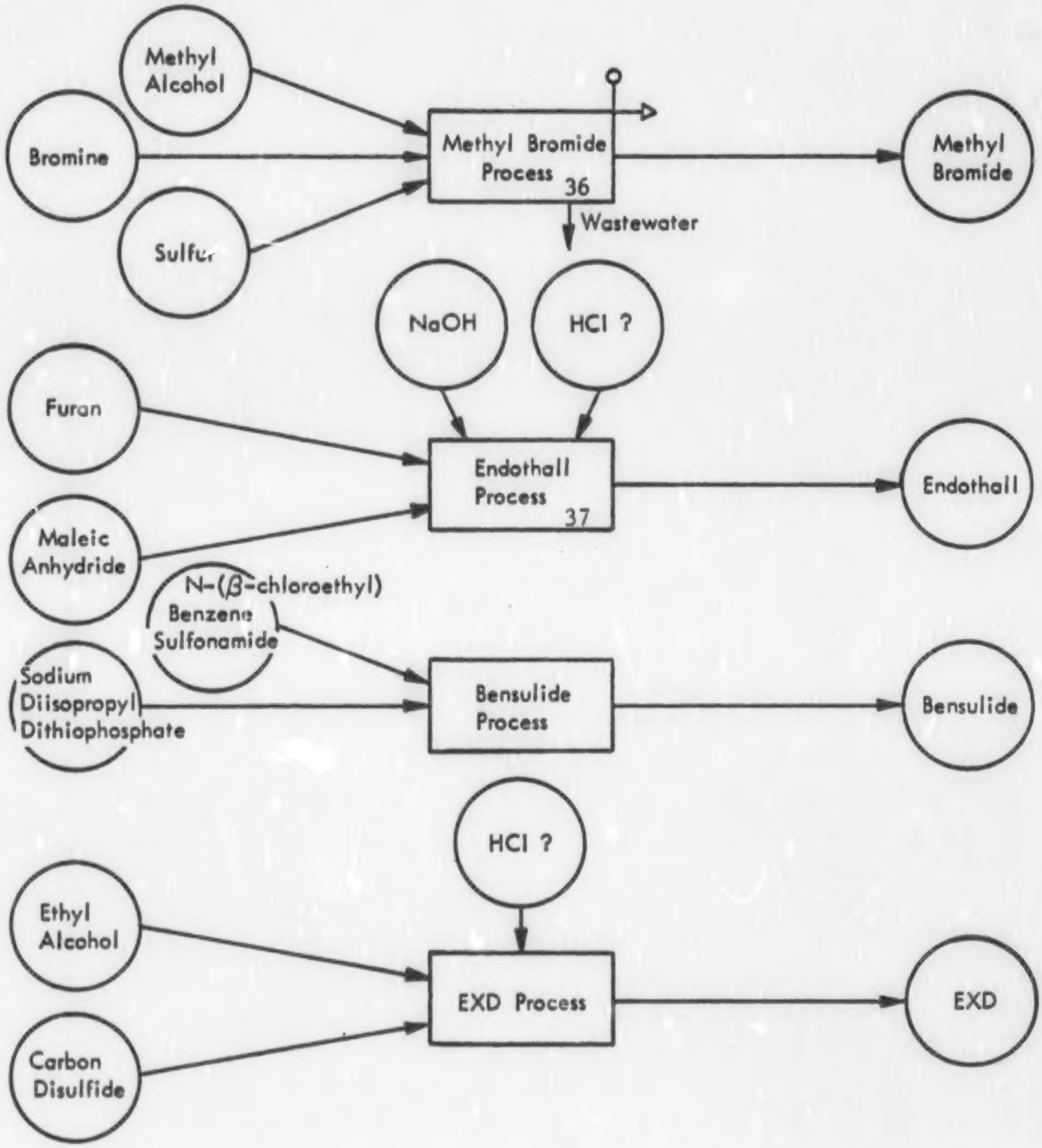

Methyl Alcohol
Bromine
Sulfur
Methyl Bromide Process
36
Wastewater
Methyl Bromide
NaOH
HCl ?
Furan
Endothall Process
37
Endothall
Maleic Anhydride
N-(β-chloroethyl) Benzene Sulfonamide
Sodium Diisopropyl Dithiophosphate
Bensulide Process
Bensulide
HCl ?
Ethyl Alcohol
EXD Process
EXD
Carbon Disulfide

Figure 30. Flow sheet for other pesticide processes

Methyl Bromide Process

1. Function - Methyl bromide is prepared by a simple bromination process using methanol, elemental bromine, and sulfur. The input materials are reacted in a fractionation system to form methyl bromide (CH_3Br) and sulfuric acid. The CH_3Br is dried with silica gel and packaged.

2. Input Materials - Methanol, bromine, and sulfur.

3. Operating Parameters - Data not available.

4. Utilities - Data not available.

5. Waste Streams - The H_2SO_4 is recovered. The fumes are scrubbed with NaOH, treated and discharged. The wastewater from the scrubbing process may possibly contain Na_2SO_4.

6. EPA Source Classification Code - None exists.

7. Reference -

von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

Endothall Process

1. Function - Endothall is produced by a Diels-Alder condensation reaction of furan and maleic anhydride followed by a reduction reaction or a NaOH addition reaction. The NaOH reaction yields the endothall--Na salt.

2. Input Materials - Furan and maleic anhydride plus a reducing agent (HCl) or NaOH to form the Na salt.

3. Operating Parameters
   - Temperature: This reaction is conducted at a temperature of about 35°C.
   - Pressure: The furan-maleic anhydride condensation is carried out at atmospheric pressure.
   - Reaction time: A reaction time of about 7 hr is sufficient for the condensation of furan and maleic anhydride at a temperature of 35°C.
   - Reaction medium: This reaction is carried out in the liquid phase. Isopropyl ether may be used as a reaction diluent.

4. Utilities - Data not available.

5. Waste Streams - Data not available.

6. EPA Source Classification Code - None exists.

7. Reference -

Sittig, M., Pesticide Production Processes 1967, Noyes Development Corporation (NDC), Chemical Process Review No. 5 (1967).

APPENDIX A

LISTS OF PROCESS INPUT MATERIALS FOR THE PESTICIDES INDUSTRY

Table A-1. CHLORINATED HYDROCARBON PESTICIDES

Pesticide	Input materials
Toxaphene	Chlorine, α-pinene
Strobane	Chlorine, mixed terpenes
Bandane	Chlorine, bicyclopentadiene
Ethylene dichloride	Chlorine, ethylene
Hexachloracetone	Chlorine, acetone
Chloroacetic acid	Chlorine, acetic acid
TCA	Chlorine, acetic acid (3 moles)
Dalapon	Chlorine, propionic acid
PCNB	Chlorine, nitrobenzene
Dacthal (DCPA)	Chlorine, C_6H_4 $(COCl)_2$, CH_3ONa
Dicamba	Chlorine, benzene methanol, CO_2, $(CH_3)_2SO_4$
2,3,6-TBA	Chlorine, toluene, oxygen
Chloramben	Chlorine, benzoic acid, ammonia
Methoxychlor	Chlorine, ethanol, anisole
DDD	Chlorine, ethanol, chlorobenzene
DDT	Chlorine, ethanol, chlorobenzene
2,4,5-Trichlorophenol	Phenol, chlorine
PCP	Phenol, chlorine
2,4-D	2,4-Dichlorophenol, $ClCH_2COOH$, NaOH
2,4-DB	2,4-Dichlorophenol, butyrolactone
Dichlorobenzene	Chlorine, benzene
Hexachlorophene	2,4,5-Trichlorophenol, CH_2O
2,4,5-T	2,4,5-Trichlorophenol, NaOH, $ClCH_2COOH$
Silvex	2,4,5-Trichlorophenol, NaOH, $Cl(CH_2)_2COOH$
Hexachlorobenzene	Chlorine, benzene, catalyst
Benzene hexachloride	Chlorine, benzene, UV light source
MCPA	4-Chloro-o-cresol, sodium monochloroacetate
MCPB	4-Chloro-o-cresol, butyrolactone
Bromoxynil[a]	4-Hydroxybenzaldehyde, bromine, (NH_2OH)
Dichloropropene	1,3-Dichloro-2-propanol, $POCl_3$

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[a] Bromoxynil is classified as a phenoxie but is brominated instead of chlorinated.

Table A-2. DIENE-BASED PESTICIDES

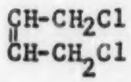
Pesticide	Input materials (1 mole/mole base)
Aldrin	Hexachlorocyclopentadiene; bicyclo-(2.2.1)-2,5 heptadiene
Dieldrin	Aldrin; H_2O_2; acetic acid
Chlordane	Hexachlorocyclopentadiene; cyclopentadiene; Cl_2
Heptachlor	Hexachlorocyclopentadiene; cyclopentadiene; $AlCl_3$ or SO_2Cl_2 + benzoyl peroxide in benzene
Isodrin	Hexachlorocyclopentadiene; vinyl chloride (or acetylene); cyclopentadiene
Endrin	Isodrin (or ingredients); H_2O_2; acetic acid
Endosulfan	Hexachlorocyclopentadiene; cis-2-butane-1,4-diol; thionyl chloride
Isobenzan (telodrin)	Hexachlorocyclopentadiene (2 moles); 2,5-dihydrofuran; Cl_2
Alodan	Hexachlorocyclopentadiene;  $\begin{array}{l} \text{CH-CH}_2\text{Cl} \\ \| \\ \text{CH-CH}_2\text{Cl} \end{array}$
Bromodan	Hexachlorocyclopentadiene; $CH_2 = CHCH_2Br$
Kepone	Hexachlorocyclopentadiene; SO_3; H_2O
Mirex	Hexachlorocyclopentadiene; $AlCl_3$
Pentac	Hexachlorocyclopentadiene; H_2 or Cu

Table A-3. ORGANOPHOSPHATE PESTICIDES

Pesticide	Input materials
Acyclic:	
Aspon	o-o-Di-n-propyl phosphorochloridothioate, water, pyridine and sodium carbonate
DEF	Butyl mercaptan and phosphorus oxychloride
Demeton	o-o-Diethyl phosphorochloridothioate and 2-hydroxethyl ethyl sulfide
Dichlorvos	Trimethyl phosphite and chloral (Alternate: triclorfon)
Dicrotophos	Trimethyl phosphite and N,N-dimethyl methyl-2-chloroacetoacetamide
Dimethoate	Sodium dimethylphosphorodithioate and N-methyl-α-chloroacetamide
Disulfoton	Sodium diethylphosphorodithioate and β-chloroethyl thioethyl ether
Ethion	o-o-Diethyl phosphorodithioic acid and dibromomethane
Malathion	o-o-Dimethyl phosphorodithioic acid and diethyl maleate
Merphos	Butyl mercaptan and phosphorus trichloride (alternate: dibutyldisulfide and phosphorus)
Mevinphos	Trimethyl phosphate and methyl-2-chloroacetoacetate
Monitor	o-o-Dimethylphosphoroamidothioate
Monocrotophos	Trimethyl phosphite and N-methyl methyl-2-chloroacetoacetamine
Naled	Dichlorvos and bromine
Methyl demeton (oxydemeton)	Dimethyl phosphorochloridothioate and 2-hydroxyethyl ethyl sulfide
Phorate	o-o-Diethyl phosphorodithioic acid, formaldehyde and ethyl mercaptan
TEPP	Diethyl phosphorochloridothioate and water (with pyridine and sodium carbanate)
Phosphamidon	Trimethyl phosphite, sulfurylchloride and acetoacetic acid diethylamide
Trichlorfon	Dimethyl phosphite and chloral

Table A-3. (Concluded)

Pesticide	Input materials
Cyclic:	
Abate	Dimethyl phosphorochloridothionate and bis-(P-hydroxyphenyl) sulfide
Azinphos-methyl	o-o-Dimethyl phosphorodithioic acid and N-chloromethylbenzazimide
Carbophenothion	o-o-Diethyl phosphorodithioic acid and N-chloromethylbenzazimide
Dursban (clopyrifos)	Sodium diethylphosphorodithioate and 4-chlorophenyl chloromethyl sulfide
Crotoxyphos	Diethyl phosphorochloridothioate and 3,5,6-trichloro-2-pyridinol
Coumaphos	Diethyl phosphorochloridothionate and 3-chloro-4-methyl-7-hydroxycoumarin
Crufomate	4-t-Butyl-2-chlorophenol, phosphonyl chloride, methanol, methylamine
Diazinon	Diethyl phoshporochloridothionate and 2-isopropyl-4-methyl-6-hydroxyprimidine
Dioxathion	o-o-Diethyl phosphorodithioic acid and 2,3-dichloro-p-dioxane
Dyfonate (fonophos)	No data
Dasanit (fensulfothion)	Diethyl phosphorochloridothioate and 4-methylthio-1-hydroxybenzene
Fenthion	Dimethyl phosphorochloridothionate and 4-methylthio-m-cresol
Methyl parathion	Dimethyl phosphorochloridothioate and sodium 4-nitrophenate
Parathion	Diethyl phosphorochloridothioate and sodium 4-nitrophenate
Phosmet (Imidan)	Sodium dimethylphosphorodithioate phthalimide, formaldehyde and chlorine
Fenchlorophos (Ronnel)	2,4,5-Trichlorophenyl phosphorochloridothioate sodium and methanol
Dicupthon	Dimethyl phosphorochloridothionate and sodium 2-chloro-4-nitrophenate
Famophos	o-o-Dimethyl phosphorochloridothioate, N,N-dimethyl-1-phenol-sulfonomide, sodium hydroxide and water

Table A-4. CARBAMATE PESTICIDES

Pesticide	Input materials
Carbamates and thio-:	
Aldicarb	Dimethylethylene, sodium nitrate, HCl, methylthiosodium and methylisocyanate
Barban	4-Chloro-2-butynol and 3-chlorophenylisocyanate (Alternate: 4-chloro-2-butynol, 3-chloroaniline)
Butylate	Diisobutylamine, phosgene and ethyl mercaptan
Carbaryl	1-Napthyl-chloroformate, methylamine and sodium hydroxide
Carbofuran	2,3-Dihydro-2,2-dimethyl-7-benzofuranol and methyl isocyanate
Chloroprophan	*m*-chloroaniline and isopropyl chloroformate
Cycloate	N-ethylcyclohexylamine and ethylchlorothioformate
Di-allate	Diisopropylamine, phosgene and 2,3-dichloropropenyl-1-thiol
EPTC	Di-*n*-propylamine, phosgene and ethyl mercaptan (Alternate: di-*n*-propylamine and ethylchlorothioformate)
Molinate	Hexamethyleneimine and ethylchlorothioformate
Pebulate	Ethyl-*n*-butylamine, phosgene and n-propyl mercaptan (Alternate: ethyl-*n*-butylamine and n-propylchlorothioformate)
Propham	Aniline and isopropyl chloroformate
Tri-allate	Diisopropylamine, phosgene and 2,3,3-trichlorophenyl-1-thiol
Vernolate	Di-*n*-propylamine, phosgene and n-propyl mercaptan
Dithiocarbamates:	
CDEC	Diethylamine, carbon disulfide, sodium hydroxide and 2,3-dichloropropene
Dimethyldithiocarbamic acid, K salt	Dimethylamine, carbon disulfide and potassium hydroxide
Dimethyldithiocarbamic acid, Mn salt	K salt (above) or Na salt and manganese sulfate (or chloride)
Ethylene-bis(dithiocarbamic acid), diammonium salt ferban	Ethylenediamine, carbon disulfide and ammonia
Ferban	Dimethylamine, carbon disulfide, sodium hydroxide and iron salt (chloride or sulfate)
Metham	Methylamine, carbon disulfide and sodium hydroxide
Nabam	Ethylenediamine, carbon disulfide and sodium hydroxide
Maneb	Nabam and manganese salt (chloride or sulfate)
Zineb	Nabam and zinc salt (chloride or sulfate)

Table A-5. TRIAZINE PESTICIDES

Pesticide	Input materials (1 mole/mole base)
Ametryne®	Atrazine, methyl mercaptan
Atrazone	Atrazine, methyl alcohol
Atrazine	Cyanuric chloride, ethylamine, $(CH_3)CHNH_2$
Bladex®	Ethylamine, cyanuric chloride $(CH_3)_2C(CN)NH_2$
Chlorazine	Cyanuric chloride, $(C_2H_5)_2NH$, $CIC_6H_4NH_2$
Cyprazine	Cyanuric chloride, CH_2CH_2CHNH
Dyrene®	Ortho-Chloroaniline, cyanuric chloride
Igran 80W® (Terbutryne)	Cyanuric chloride, ethylamine, $(CH_3)_3CNH_2$, methyl mercaptan
MPMT	Cyanuric chloride, $CH_3O(CH_2)_3NH_2$ (2 moles)
Prometone	Propazine, methyl mercaptan
Prometryne	Propazine, methyl alcohol
Propazine	Cyanuric chloride, $(CH_3)_2CHNH$ (2 moles)
Simazine	Cyanuric chloride, ethylamine (2 moles)
Trietazine	Cyanuric chloride, ethylamine (2 moles)

Table A-6. ANILIDE PESTICIDES

Pesticide	Input materials
Alachlor	Diethylaniline, paraformaldehyde, chloroacetyl chloride, anhydrous ammonia, methanol
Butachlor	Diethylaniline, paraformaldehyde, chloroacetyl chloride, anhydrous ammonia, butanol
Propachlor	Aniline, paraformaldehyde, chloroacetyl chloride, anhydrous ammonia, isopropanol
Propanil	3,4-Dichloroaniline, propionic acid, thionyl chloride

Table A-7. UREA AND URACIL PESTICIDES

Pesticide substituted ureas	Input materials
Diuron	3,4-Dichloroaniline, phosgene and dimethylamine (Alternate: 3,4-dichloroaniline, urea and dimethylamine)
Linuron	3,4-Dichloroaniline, phosgene and O,N-dimethyl hydroxylamine
Fluometuron	3-Trifluoromethyl aniline, phosgene and dimethylamine
Siduron	Aniline, phosgene and 2-methylcyclohexylamine
Chloroxuron	4-(4-Chlorophenoxy) aniline, phosgene and dimethylamine
Monuron	p-Chloroaniline, phosgene and dimethylamine (Alternate: p-chloroaniline, urea and dimethylamine)
Monuron-TCA	Monuron and trichloroacetic acid
Uracils	
Bromacil	sec-Butylamine, phosgene, ammonia, ethylacetoacetate and bromine
Terbacil	sec-Butylamine, phosgene, ammonia, ethylacetoacetate and chlorine

Table A-8. NITRATED HYDROCARBON PESTICIDES

Pesticide	Input materials
Trifluralin	HNO_3/H_2SO_4, chloro-4-trifluoromethylbenzene and dipropylamine
Benefin	HNO_3/H_2SO_4, chloro-4-trifluoromethylbenzene and butylethylamine
Dinoseb	HNO_3/H_2SO_4, o-sec-butylphenol
DNOC	o-Cresol, H_2SO_4 and HNO_3/H_2SO_4
Nitrofen	2,4-Dichlorophenate and p-chloronitrobenzene
Chloropicrin	Nitromethane, chlorine and sodium hydroxide

Table A-9. OTHER NITROGENOUS PESTICIDES

Pesticide	Input materials
Captafol	Sodium hydroxide, 1,1,2,2-tetrachloroethylsulphenyl chloride and tetrahydrophthalimide
Captan	Sodium hydroxide, trichloromethylsulphenyl chloride and tetrahydrophthalimide
Folpet	Sodium hydroxide, trichloromethylsulphenyl chloride and phthalimide
DCAA	Chloroacetyl chloride and diallyamine
Diphenamid	Sodium hydroxide, dimethylcurbamyl chloride and diphenylmethane
Deet	*m*-Toluyl chloride and diethylamine
Naphthalam	Phthalic acid and 1-naphthylamine
Methomyl	(Data not available)
Benomyl	(Data not available)
Lethane 384	Butyl "carbitol" chloride and sodium thiocyanate
Methyl isothiocyanate	Ethyl chlorocarbamate and N-methyldithiocarbamate
Nitralin	Chlorine and ispchtaldodinitrile
Maleic hydrazide	Maleic anhydride and dihydrazine sulfate
Dodine	Dodecyl chloride, sodium cyanide, ammonia and acetic acid
Pichloram	Chlorine, α-picoline, sulfuric acid and ammonia

Table A-10. ARSENICAL AND METALLIC PESTICIDES

Pesticide	Input materials
Organoarsenicals	
DSMA	Arsenic trioxide, sodium hydroxide, methyl chloride
MSMA	DSMA (or materials) and sulfuric acid
Methyl arsenic acid	DSMA (or materials) and sulfuric acid
Cacodylic acid	DSMA (or materials), sulfur dioxide, sodium hydroxide, and hydrochloric acid
Organometallics	
PMA	Mercuric acetate and benzene
Phenyl mercuric oleate	Mercuric oleate and benzene
Copper naphthenates	Copper salts and naphthenic acids

Table A-11. OTHER ORGANIC PESTICIDES

Pesticide	Input materials
Methyl bromide	Methyl alcohol, bromide and sulfur (Alternate: methyl alcohol and hydrobromic acid)
Endothall	Furan and maleic anhydride (plus reducing or oxidizing agent)
Bensulide	N-(β-chloroethyl)benzene sulfonamide and potassium diisopropyl dithiophosphate
EXD	Ethyl alcohol, carbon disulfide, sodium hydroxide and an oxidizer (HCl or H_2SO_4)

Input Material Reference Sources

(1) Lawless, E. W., R. von Rümker, and T. L. Ferguson, The Pollution Potential in Pesticide Manufacture, Midwest Research Institute for the U.S. EPA, Office of Water Programs, Technical Studies Report No. TS-00-72-04, June 1972.

(2) von Rümker, R., E. W. Lawless, and A. F. Meiners, Production, Use, and Environmental Impact Potential of Selected Pesticides, Midwest Research Institute for Council on Environmental Quality, Contract EQC-311, Final Report, 15 March 1974.

(3) Sittig, M., Pesticide Production Processes 1967, Noyes Development Corporation (1967).

(4) Sittig, M., Agricultural Chemicals Manufacture, Noyes Development Corporation, Chemical Process Review No. 52 (1971).

(5) Martin, H., Pesticide Manual, British Crop Protection Council, Second Edition (1972).

APPENDIX B

U.S. TARIFF COMMISSION LIST OF PESTICIDES

PESTICIDES AND RELATED PRODUCTS, CYCLIC

Fungicides:
- Benzylbromo acetate
- 2,6-Bis(dimethylaminomethyl)cyclohexanone
- 2'-Bromo-4'-hydroxyacetophenone
- 5-Chloro-2-benzothiazolethiol, laurylpyridinium salt
- Cyanomethylthiobenzothiazole
- 2,4-Dichloro-6-(o-chloroanilino)-s-triazine
- 1,4-Dichloro-2,5-dimethoxybenzene (Chloroneb)
- 1,2-Dihydro-6-ethoxy-2,2,4-trimethylquinoline (Ethoxyquin)
- 3,5-Dimethyl-1,3,5-2H-tetrahydrothiadiazine-2-thione (DMTT).
- Diphenylammonium propionate
- 5-Ethoxy-3-trichloromethyl-1,2,4-thiadiazole
- Hexahydro-1.3,5-triethyl-s-triazine
- Hexahydro-1,3,5-tris(2-hydroxyethyl)-s-triazine
- 2-Mercaptobenzothiazole, monoethanolamine salt
- Mercury fungicides:
  - Diphenylmercury dodecenylsuccinate
  - Phenylmercuric acetate (PMA)
  - Phenylmercuric ammonium acetate
  - Phenylmercuric dimethyldithiocarbamate
  - Phenylmercuric hydroxide
  - Phenylmercuric lactate
  - Phenylmercuric oleate
  - Phenylmercuric propionate
  - Phenylmercuric succinate
  - All other mercury fungicides
- Methyl-N-benzimidazol-2-yl-N-(butylcarbomoyl) carbamate (Benomyl).
- 2-(1-Methyl-n-heptyl)-4,6-dinitrophenyl crotonate (Dinocap).
- 3-(2-Methylpiperidino)propyl-3,4-dichlorobenzoate (Piperalin).
- Naphthenic acid, copper salt
- Pentachloronitrobenzene (PCNB)
- Pentachlorophenol (PCP)
- Pentachlorophenol, sodium salt
- 8-Quinolinol (8-Hydroxyquinoline), copper salt
- N-(1,1,2,1-Tetrachloro-ethylsulfenyl)-cis-∇-4-cyclohexene-1,2-dicarboximide (Captafol).
- 2,4,5,6-Tetrachloroisophthalonitrile
- 2,3,4,6-Tetrachlorophenol
- N-Trichloromethylthio-4-cyclohexene-1,2-dicarboximide (Captan).
- N-Trichloromethylthiophthalimide (Folpet)
- 2,4,5-Trichlorophenol acid and salts:
  - 2,4,5-Trichlorophenol
  - 2,4,5-Trichlorophenol, ethanolamine salt
  - 2,4,5-Trichlorophenol, sodium salt
- 2,4,6-Trichlorophenol

Herbicides and plant hormones:
- 4-Amino-3,5,6-trichloropicolinic acid (Picloram)
- 2,4-Bis(isopropylamino)-6-methylthio-s-triazine (Prometryn).
- 5-Bromo-3-sec-butyl-6-methyluracil (Bromacil)
- 3-tert-Butyl-5-chloro-6-methyluracil (Terbacil)
- N-Butyl-N-ethyl-α,α,α-trifluoro-2,6-dinitro-p-toluidine (Benefin).
- 2-Butynyl-4-chloro-m-chlorocarbanilate (Barban)
- 2-Chloro-4,6-bis(ethylamino)-s-triazine (Simazine)
- 2-Chloro-4,6-bis(isopropylamino)-s-triazine (Propazine)
- 2-Chloro-2',6'-diethyl-N-(n-butoxymethyl)acetanilide
- 2-Chloro-2',6'-diethyl-N-(methoxymethyl)acetanilide (Alachlor).
- 2-Chloro-4-ethylamino-6-isopropylamino-s-triazine (Atrazine).
- 2-Chloro-N-isopropylacetanilide (Propachlor)
- 4-Chloro-2-methylphenoxy butyric acid
- N'-(4-Chlorophenoxy)phenyl N,N-dimethylurea (Chloroxuron).
- 3-(p-Chlorophenyl)-1,1-dimethylurea (Monuron)
- 3-(p-Chlorophenyl)-1,1-dimethylurea trichloroacetate
- 2;5-Dichloro-3-aminobenzoic acid, ammonium salt
- 2,5-Dichloro-3-aminobenzoic acid, methyl ester
- 3,6-Dichloro-2-anisic acid (Dicamba)
- 2,4-Dichlorobenzyltributylphosphonium chloride
- 2,5-Dichloro-6-nitrobenzoic acid, sodium salt
- 4-(2,4-Dichlorophenoxy)butyric acid (2,4-DB)
- 3-(3,4-Dichlorophenyl)-1,1-dimethylurea (Diuron)
- 3-(3,4-Dichlorophenyl)-1-methoxy-1-methylurea (Linuron)
- 2,4-Dichlorophenyl-4-nitrophenyl ether (Nitrofen)
- 3',4'-Dichloropropionanilide (Propanil)
- 1,2-Dihydropyridazine-3,6-dione (Maleic hydrazide)(MH)
- N-(beta-O,O-Diisopropyl-dithiophosphorylethyl)benzene sulfonamide (Bensulide).
- N,N-Dimethyl-2,2-diphenylacetamide (Diphenamid)
- Dimethyl-2,3,5,6-tetrachloroterephthalate (DCPA)
- Dinitrobutylphenol (DNBP)
- Dinitrobutylphenol, ammonium salt
- Dinitrobutylphenol, triethanolamine salt
- Dinitrocresol, sodium salt
- 2-Ethylamino-4-isopropylamino-6-methylmercapto-s-triazine (Ametryne).
- S-Ethyl(cyclohexyl)ethylthiocarbamate
- S-Ethyl hexahydro-1H-azepine-1-carbothioate (Molinate)
- Gibberellic acid
- 3-Indolebutyric acid
- Isopropyl N-(3-chlorophenyl)carbamate (CIPC)
- Isopropyl N-phenylcarbamate (IPC)
- 1-(2-Methylcyclohexyl)-3-phenylurea (Siduron)
- 4-(Methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline (Nitralin).
- 1-Naphthaleneacetic acid and derivatives:
  - 1-Naphthaleneacetamide
  - 1-Naphthaleneacetic acid (NAA)
  - 1-Naphthaleneacetic acid, sodium salt
- N-1-Naphthylphthalamic acid (NPA)
- 7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid, disodium salt (Endothall).
- Phenoxyacetic acid derivatives:
  - 4-Chloro-2-methylphenoxyacetic acid (MCPA)
  - 3,5-Dibromo-4-hydroxybenzonitrile, octanoic acid ester (Bromoxynil octanoate).
  - 2,4-Dichlorophenoxyacetic acid (2,4-D)
  - 2,4-Dichlorophenoxyacetic acid esters and salts:
    - 2,4-Dichlorophenoxyacetic acid, 2-butoxyethyl ester
    - 2,4-Dichlorophenoxyacetic acid, butoxypolypropyleneglycol ester.
    - 2,4-Dichlorophenoxyacetic acid, n-butyl ester
    - 2,4-Dichlorophenoxyacetic acid, sec-butyl ester
    - 2,4-Dichlorophenoxyacetic acid, dimethylamine salt
    - 2,4-Dichlorophenoxyacetic acid, ethanolamine and isopropanolamine salt.
    - 2,4-Dichlorophenoxyacetic acid, iso-octyl ester
    - 2,4-Dichlorophenoxyacetic acid, isopropyl ester
    - 2,4-Dichlorophenoxyacetic acid, lithium salt
    - 2,4-Dichlorophenoxyacetic acid, sodium salt
  - 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T)
  - 2,4,5-Trichlorophenoxyacetic acid esters and salts:
    - 2,4,5-Trichlorophenoxyacetic acid, 2-butoxyethyl ester.
    - 2,4,5-Trichlorophenoxyacetic acid, butoxypolypropyleneglycol ester.
    - 2,4,5-Trichlorophenoxyacetic acid, n-butyl ester
    - 2,4,5-Trichlorophenoxyacetic acid, sec-butyl ester
    - 2,4,5-Trichlorophenoxyacetic acid, iso-octyl ester
    - 2,4,5-Trichlorophenoxyacetic acid, triethylamine salt.
- Polychloro-tetrahydro-methanoindene (Polychlorodicyclopentadiene) isomers.
- 2-(2,4,5-Trichlorophenoxy)propionic acid (Silvex)
- 2-(2,4,5-Trichlorophenoxy)propionic acid esters and salts:
  - 2-(2,4,5-Trichlorophenoxy)propionic acid, 2-butoxyethyl ester.
  - 2-(2,4,5-Trichlorophenoxy)propionic acid, iso-octyl ester.
- α,α,α-Trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (Trifluralin).
- 3-(m-Trifluoromethylphenyl)-1,1-dimethylurea (Fluometuron).
- All other cyclic herbicides

Insect attractants and repellents:
- tert-Butyl 4(and 5)-chloro-2-methylcyclohexanecarboxylate (Trimedlure).

Source: *Synthetic Organic Chemicals, United States Production and Sales, 1972*, U.S. Tariff Commission

PESTICIDES AND RELATED PRODUCTS, CYCLIC--Continued

2-(3,4-Dichlorophenyl)-1,2,4-oxadiazoline-4-methyl-3,5-dione.
N,N-Diethyltoluamide (DEET)
Di-n-propylisocinchomeronate
Insecticides:
3-sec-Amylphenyl-N-methylcarbamate
Bacillus thuringiensis
2-sec-Butyl-4,6-dinitrophenyl-3,3-dimethylacrylate (Binapacryl).
2-(p-tert-Butylphenoxy)cyclohexyl-2'-propynyl sulfite
o-sec-Butylphenyl-N-methylcarbamate
Chlorinated insecticides:
Aldrin-toxaphene group:
Heptachloro-tetrahydro-endo-methanoindene (Heptachlor).
Hexachloro-epoxy-octahydro-endo, endo-dimethanonaphthalene (Endrin).
Hexachloro-epoxy-octahydro-endo, exo-dimethano naphthalene (Dieldrin).
Hexachloro-hexahydro-endo, exo-dimethanonaphthalene (Aldrin).
Octachloro-hexahydro-methanoindene (Chlordan)
Toxaphene (Chlorinated camphene)
2,2-Bis(p-chlorophenyl)-1,1-dichloroethane (DDD) (TDE)
α-Bis(p-chlorophenyl)β,β,β-trichloroethane (DDT)
Chlorobenzilate
o-Chlorophenyl-N-methylcarbamate
p-Chlorophenyl 2,4,5-trichlorophenyl sulfone (Tetradifon).
Decachlorooctahydro-1,3,4-metheno-2H-cyclobuta-[cd] pentalen-2-one (Kepone).
1,1-Dichloro-2,2-bis(p-ethylphenyl)ethane
4,4'-Dichloro-α-trichloromethylbenzhydrol (Dicofol)
2,6-Dimethyl-3,5-dichloro-4-pyridinol
Dodecachlorooctahydro-1,3,4-metheno-2H-cyclobuta-[cd] pentalene (Mirex).
Hexachlorocyclohexane (Benzene hexachloride) (BHC)
Hexachlorocyclohexane, 100% γ-isomer (Lindane)
Hexachloro-hexahydro-methano-benzodioxathiepin 3-oxide (Endosulfan).
Isopropyl 4,4'-dichlorobenzilate (Chloropropylate)
1,1,1-Trichloro-2,2-bis(p-methoxyphenyl)ethano (Methoxychlor).
2,3-Dihydro-2,2-dimethyl-7-benzofuranly methylcarbamate (Carbofuran).
m-[[(Dimethylamino)methylene]amino]phenyl methyl carbamate hydrochloride (Formetanate hydrochloride).
m-(1-Ethylpropyl)phenyl methylcarbamate
0-Isopropylphenyl N-methylcarbamate
m-(1-Methylbutyl)phenyl methylcarbamate
1-Naphthyl N-methylcarbamate (Carbaryl)
Organophosphorus insecticides:
0-(4-Bromo-2,5-dichlorophenyl)0-methyl phenylphosphonothioate (Leptophos).
4-tert-Butyl-2-chlorophenylmethyl methylphosphoramidite.
S-[[(p-Chlorophenyl)thio]methyl] 0,0-diethyl phosphorodithioate (Carbophenothion).
0,0-Diethyl 0-3-chloro-4-methyl-1-oxo-2H-1-benzopyran-7-yl-phosphorothioate (Coumaphos).
0,0-Diethyl 0-(2-isopropyl-4-methyl-6-pyrimidinyl)-phosphorothioate (Diazinon).
0,0-Diethyl 0-[p-(methylsulfinyl)phenyl] phosphorothioate (Fensulfothion).
0,0-Diethyl 0-p-nitrophenyl phosphorothioate (Parathion).
0,0-Diethyl 0-3,5,6-trichloro-2 pyridyl phosphorothioate.
0,0-Dimethyl 0-[4-(methylthio)-m-tolyl]phosphorothioate (Fenthion).
0,0-Dimethyl 0-p-nitrophenyl phosphorothioate (Methyl parathion).
0,0-Dimethyl S-[4-oxo-1,2,3-benzotriazin-3(4H)-ylmethyl] phosphorodithioate (Azinphosmethyl).
0,0-Dimethyl S-phthalimidomethyl phosphorodithioate
Dimethyl 2,4,5-trichlorophenyl phosphorothionate (Ronnel).
2,3-p-Dioxane S,S-bis(0,0-diethylphosphorodithioate) (Dioxathion).
0-Ethyl S-phenylethylphosphonodithioate
α-Methylbenzyl 3-(dimethoxyphosphinyloxy)-cis-crotonate.
0,0,0',0'-Tetramethyl 0,0'-thiodi-p-phenylene phosphorothioate.
All other organophosphorus insecticides
N-(Phenyl-2-nitropropyl)piperidine
m-Tolyl-N-methylcarbamate
All other cyclic insecticides
Nematocides:
0,0-Diethyl 0-(2,4-dichlorophenyl) phosphorothioate (Dichlofenthion).
0,0-Diethyl 0-2-pyrazinyl phosphorothioate (Thionazin)
Rodenticides:
3-(α-Acetonylbenzyl)-4-hydroxycoumarin (Warfarin)
2-Diphenylacetyl-1,3-indandione and sodium salt (Diphacinone).
2-Pivaloyl-1,3-indandione (Pindone)
Synergists and adjuvants:
α-[2-(2-m-Butoxyethoxy)-ethoxy]-4,5-methylenedioxy-2-propyltoluene (Piperonyl butoxide).
N-(2-Ethylhexyl)bicyclo)2.2.1)-5-heptene-2,3-dicarboximide.
1,2-Methylenedioxy-4-[2-(octylsulfinyl)propyl]benzene
Piperonal bis[2-(2'-n-butoxyethoxy)ethyl]acetal (Heliotropin acetal).
All other cyclic pesticides and related products

PESTICIDES AND RELATED PRODUCTS, ACYCLIC

Fungicides:
Bis-1,4-bromoacetoxy-2-butene
N,N-Bis(phosphonomethyl)glycine
Cadmium succinate
1-Chloro-2-nitropropane (Korax)
Copper tallate
Dimethylthiocarbonyl disulfide
Disodium cyanodithioimidocarbamate
Dithiocarbamic acid fungicides:
Dimethyldithiocarbamic acid, ferric salt (Ferbam)
Dimethyldithiocarbamic acid, manganese salt
Dimethyldithiocarbamic acid, potassium salt
Ethylene bis(dithiocarbamic acid), diammonium salt
Ethylene bis(dithiocarbamic acid), disodium salt (Nabam).
Ethylene bis(dithiocarbamic acid), manganese salt (Maneb).
Ethylene bis(dithiocarbamic acid), zinc salt (Zineb)
N-Methyldithiocarbamic acid, sodium salt (SMDC)
All other dithiocarbamic acid fungicides
n-Dodecylguanidine acetate (Dodine)
2-Hydroxypropylmethanethiol sulfonate
Chloromethoxypropylmercuric acetate
Polyethylenethiuram disulfide (PETD)
Herbicides and plant hormones:
2-Chloroallyl diethyldithiocarbamate (CDEC)
2-Chloro-N,N-diallylacetamide (CDAA)
(2-Chloroethyl)phosphonic acid
S-2,3-Dichloroallyl diisopropylthiolcarbamate (Diallate).
2,2-Dichloropropionic acid, sodium salt (Dalapon)
N-Dimethylamino succinamic acid (DMSA)
Dimethylarsinic acid (Cacodylic acid)
Ethyl diisobutyl thiolcarbamated
S-Ethyl N,N-dipropylthiolcarbamate (EPTC)
Ethyl xanthogen disulfide (EXD)
Methanearsonic acid, disodium salt (DSMA)
Methanearsonic acid, dodecyl- and octylammonium salt
Methanearsonic acid, monosodium salt (MSMA)
S-Propyl butylethylthiocarbamate (Pebulate)
S-Propyl dipropylthiocarbamate (Vernolate)
S,S,S-Tributyl phosphorotrithioate
Tributyl phosphorotrithioite
Trichloroacetic acid, sodium salt (TCA)
S-2,2,3-Trichloroallyl diisopropylthiolcarbamate (Triallate).
All other acyclic herbicides

PESTICIDES AND RELATED PRODUCTS, ACYCLIC--Continued

- Insecticides:
  - 2-(2-Butoxyethoxy)ethyl thiocyanate
  - S-Methyl N-[(methylcarbamoyl)oxy]thioacetimidate (Methomyl).
  - Organophosphorus insecticides:
    - S-[1,2-Bis(ethoxycarbonyl)ethyl] 0,0-dimethyl phosphorodithioate (Malathion).
    - 2-Carbomethoxy-1-propen-2yl dimethyl phosphate (Mevinphos).
    - 1,2-Dibromo-2,2-dichloroethyl dimethyl phosphate (Naled).
    - 0,0-Diethyl S-2-(ethylthio)ethyl phosphorodithioate (Disulfoton).
    - 0,0-Diethyl 0-2-(ethylthio)ethyl phosphorothioate (Demeton 0).
    - 0,0-Diethyl S-(ethylthio)methyl phosphorodithioate (Phorate).
    - 3-(Dimethoxyphosphinyloxy)-N,N-dimethyl-cis-crotonamide (Dicrotophos).
    - 0,0-Dimethyl 2,2-dichlorovinyl phosphate (Dichlorvos).
    - 0,0-Dimethyl S-[2-ethylsulfinyl)ethyl]phosphorothioate (Oxydemetonmethyl).
    - 0,0-Dimethyl S-(N-methylcarbamoylmethyl)phosphorodithioate (Dimethoate).
    - Dimethyl phosphate of 3-hydroxy-N-methyl-cis-crotonamide (Monocrotophos).
    - 0,S-Dimethyl phosphoramidothioate
    - 0,0,0',0'-Tetraethyl S,S'-methylene bisphosphorodithioate (Ethion).
    - Tetraethyl pyrophosphate (TEPP)
    - 0,0,0,0-Tetra-n-propyl dithiopyrophosphate
  - All other acyclic insecticides
- Nematocides:
  - 0-Ethyl S,S-dipropyl phosphorodithioate
  - 2-Methyl-2(methylthio)propionaldehyde 0-(methylcarbamoyl)oxime (Aldicarb).
- Soil conditioners: Polyacrylonitrile, hydrolyzed, sodium salt
- Soil fumigants:
  - 1,2-Dibromo-3-chloropropane (DBCP)
  - 1,3-Dichloropropene
  - 1,3-Dichloropropene, 1,2-dichloropropane
  - Methyl bromide (Bromomethane)
  - Methyl isothiocyanate
  - Trichloronitromethane (Chloropicrin)

APPENDIX C

STANFORD RESEARCH INSTITUTE LIST OF PESTICIDES AND PRODUCERS

Pesticides

The following revised Pesticides grouping is based upon information received from producing companies and the 1968 Report (Synthetic Organic Chemicals--U.S. Production and Sales) of the United States Tariff Commission (issued in July 1970).

Pesticides and related products are often better known by trade and brand names than by chemical names. Many of the more common trade and brand names are included (and cross-referenced to chemical names) below.

Other sources listing pesticides and related products, particularly their chemical names, trade names, and chemical structures are the following:

Agricultural Chemicals, (4 volumes), W. T. Thomson, Thomson Publication, Post Office Box 989, Davis, California 95616.

Pesticides Index, D. E. Frear, College Science Publishers, Post Office Box 798, State College, Pennsylvania.

Pesticide Handbook-Entoma, D. E. Frear, College Science Publishers, Post Office Box 798, State College, Pennsylvania.

AMS (See: Ammonium sulfamate)

AAtrex# (See: 2-Chloro-4-ethylamino-6-isopropylamino-s-triazine)

Abate# (See: O,O,O',O'-Tetramethyl O,O'-thiodi-p-phenylene phosphorodithioate)

Acaraben# (See: Ethyl 4,4'-dichlorobenzilate)

Acaralate# (See: Isopropyl 4,4'-dichlorobenzilate)

3-(#-Acetonylbenzyl)-4-hydroxycoumarin (See: Warfarin)

3-(#-Acetonylfurfuryl)-4-hydroxycoumarin (See: 3-[1-Furyl-3-acetylethyl]-4-hydroxycoumarin)

(Acetoxymercuri) benzene (See: Phenylmercury acetate)

Acetoxyphenylmercury (See: Phenylmercury acetate)

2-Acetyl-5-hydroxy-3-oxo-4-hexenoic acid #-lactone (See: Dehydroacetic acid in general alphabetical listing)

Acrolein

Acquinite# (See: Chloropicrin)

Acrylonitrile

Afalon (See: 3-[3,4-Dichlorophenyl]-1-methoxy-1-methylurea)

Agrox# (See: Phenylmercury urea)

Akton# (See: O,O-Diethyl O-[2-chloro-1-(2,5-dichlorophenyl) vinyl] phosphorothioate)

Alanap# (See: N-1-Naphthylphthalamic acid)

Alar# (See: N-Dimethylaminosuccinamic acid)

Aldrin (1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-endo, exo-5,8-dimethanonaphthalene) (Seedrin)
Shell Chemical Company
Agricultural Division
Denver, Colorado

Alkron# (See: O,O-Diethyl O-[p-nitrophenyl] phosphorothioate)

Allethrin (2-Allyl-4-hydroxy-3-methyl-2-cyclopenten-1-one, ester of chrysanthemummonocarboxylic acid)
McLaughlin Gormley King Company
Minneapolis, Minnesota

Allyl alcohol

Allyl aldehyde (See: Acrolein)

Aluminum phosphide
Occidental Petroleum Corporation
Hooker Chemical Corporation, subsidiary
Electrochemical and Specialties Divisions
Niagara Falls, New York

Amiben® (See: 3-Amino-2,5-dichlorobenzoic acid)

4-Amino-6-tert-butyl-3-(methylthio)-as-triazin-5[4H]-one
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri

Aminocarb (See: 4-[Dimethylamino]-m-tolyl methylcarbamate)

3-Amino-2,5-dichlorobenzoic acid (Amiben) (Chloramben) (Verbigen)
GAF Corporation
Chemical Division
Texas City, Texas
Rorer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania (Amiben®)
Fremont, California
St. Joseph, Missouri

3-Amino-2,5-dichlorobenzoic acid, ammonium salt
GAF Corporation
Chemical Division
Linden, New Jersey
Rorer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania
Clinton, Iowa
Fremont, California
St. Joseph, Missouri

3-Amino-2,5-dichlorobenzoic acid, ethyl ester
GAF Corporation
Chemical Division
Linden, New Jersey

3-Amino-2,5-dichlorobenzoic acid, methyl ester
GAF Corporation
Chemical Division
Linden, New Jersey

3-Amino-2,5-dichlorobenzoic acid, sodium salt
GAF Corporation
Chemical Division

Linden, New Jersey

3-Amino-s-triazole (3-Amino-1,2,4-triazole) (ATA)
(Amitrole)
American Cyanamid Company
Agricultural Division
Linden, New Jersey (Cytrol#)
Rorer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania

4-Amino-3,5,6-trichloropicolinic acid (Picloram)
Dow Chemical U.S.A.
Freeport, Texas (Tordon#)

Amitrole (See: 3-Amino-s-triazole)

Ammatex# (See: Ammonium sulfamate)

Ammonium (benzamidooxy) acetate
Gulf Oil Corporation
Gulf Oil Chemicals Company, division
Industrial and Specialty Chemicals Division
Pittsburg, Kansas

Ammonium sulfamate (AMS)
E. I. du Pont de Nemours & Company, Inc.
Industrial Chemicals Department
East Chicago, Indiana (Ammate#)
Linden, New Jersey

Ammonium thiocyanate

Amoben (See: 3-Amino-2,5-dichlorobenzoic acid)

Anthraquinone

Aqualin# (See: Acrolein)

Aquathol (See: 7-Oxabicyclo [2.2.1] heptane-2,3-dicarboxylic acid)

Arsenic acid

Aspon# (See: Tetra-n-propyl dithiopyrophosphate)

Atratol# (See: 2-Chloro-4-ethylamino-6-isopropyl amino-s-triazine)

Atratrone (See: 2-[Ethylamino]-4-[isopropylamino]-6-methoxy-s-triazine)

Atrazine (See: 2-Chloro-4-ethylamino-6-isopropyl amino-s-triazine)

Avadex# (See: S-2,3-Dichloroallyl diisopropylthio carbamate)

Avadex BW# (See: S-2,3,3-Trichloroallyl N,N-diisopropyl thiolcarbamate)

Azinphosethyl (See: O,O-Diethyl-s-[4-oxo-1,2,3-benzo triazin-3 (4H)-ylmethyl]-phsophorodithioate)

Azinphosmethyl (See: O,O-Dimethyl-s-[4-oxo-1,2,3-benzotriazin-3-(4H)-ylmethyl]-phosphorodithioate)

Azodrin# (See: 3-Hydroxy-N-methyl-cis-croton-amide-dimethyl phosphate)

Bacillus thuringiensis
  Abbott Laboratories
    Agricultural/Veterinary Products Division
      North Chicago, Illinois

B-Nine# (See: N-Dimethylamino succinamic acid)

BHC (See: Hexachlorocyclohexane)

Balan# (See: N-Butyl-N-ethyl-#,#,#-trifluoro-2,6-dinitro-p-toluidine)

Bandane# (See: Polychlorodicyclopentadiene isomers)

Banvel#D (See: 3,6-Dichloro-o-anisic acid)

Barban (See: 4-Chloro-2-butynyl m-chloro carbanilate)

Baygon# (See: o-Isopropoxyphenyl methyl carbamate)

Bayluscide# (See: 2',5-Dichloro-4'-nitrosalicylanilide, 2-aminoethanol salt)

Baytex# (See: O,O-Dimethyl O-[4-(methylthio)-m-tolyl] phosphorothioate)

Benefin (See: N-Butyl-N-ethyl, #,#,#-trifluoro-2,6-dinitro-p-toluidine)

Benlate# (See: Methyl-1-[butylcarbamoyl]-2-benzimidazole carbamate)

Bensulide (See: N-[#-O,O-Diisopropyldithio-
phosphorylethyl]-benzene sulfonamide)

Benzene hexachloride (See: Hexachlorocyclohexane)

Benzenesulfonic acid, 2,4-dichlorophenyl ester
(See: 2,4-Dichlorophenyl benzenesulfonate)

Benzotriazinedithiophosphoric acid, dimethoxy ester
(See: O,O-Dimethyl s-[4-oxo-1,2,3-benzotriazin-3
(4H)-ylmethyl] phosphorodithioate)

Benzylbromoacetate
Merck & Co., Inc.
Merck Chemical Division
Hawthorne, New Jersey

o-Benzyl-p-chlorophenol (4-Chloro-#-
phenyl-o-cresol)
Monsanto Company
Monsanto Industrial Chemicals Company
Sauget, Illinois (Santophen I#)
Red Devil Paint Co.
Tacoma, Washington

cis, trans-(5-Benzyl-3-furyl) methyl 2,2-dimethyl-3-
(2-methylpropenyl) cyclopropanecarboxylate
CPC International, Inc.
S. B. Penick & Company, division
Lyndhurst, New Jersey

Benzyl rhodanide (See: Benzyl thiocyanate)

Betasan# (See: N-[#-O,O-Diisopropyldithiophosphoryl
ethyl] benzene sulfonamide)

Bexide (See: Diethyl dithiobis [thionoformate])

Bidrin# (See: 3-[Dimethoxyphosphinyloxy]-N,N-
dimethyl-cis-crotonamide)

Biphenyl

Bis-1,4-bromoacetoxy-2-butene

2,3,4,5-Bis (#2-butylene)tetrahydrofurfural (Repellent 11)
McLaughlin Gormley King Company
Minneapolis, Minnesota

O,O-Bis (p-chlorophenyl) acetimidoylphosphor-
amidothioate
Baychem Corporation

Chemagro Corporation, division
Kansas City, Missouri (Gophacide#)

#,#-Bis (p-chlorophenyl) #,#,#-trichloroethane (See: DDT)

1,1-Bis (p-chlorophenyl)-2,2,2-trichloroethanol (See: 4,4'-Dichloro-#-[trichloromethyl] benzhydrol)

Bis (diethylthiocarbamoyl) disulfide

2,6-Bis (dimethylaminomethyl) cyclohexanone
Merck & Co., Inc.
Merck Chemical Division
Hawthorne, New Jersey

Bis (dimethylthiocarbamoyl) disulfide

Bis (dimethylthiocarbamoyl) sulfide

S,S-Bis (2,3-p-dioxanedithiol) O,O-diethylphosphorodithioate (See: p-Dioxane-2,3-diyl ethyl phosphorodithioate)

S-(1,2-Bis [ethoxycarbonyl] ethyl) O,O-dimethyl phosphorodithioate (See: Malathion)

2,4-Bis (ethylamino)-6-chloro-s-triazine (See: Simazine)

2,4-Bis (isopropylamino)-6-chloro-s-triazine (See: 2-Chloro-4,6-bis [isopropylamino]-s-triazine)

2,4-Bis (isopropylamino)-6-methoxy-s-triazine (See: 2-Methoxy-4,6-bis [isopropylamino]-1,3,5-triazine)

2,4-Bis (isopropylamino)-6-methylthio-s-triazine (Gesagard) (2-Methylmercapto-4,6-bis-[isopropylamino]-s-triazine) (Primaze) (Prometryne)
Ciba-Geigy Corporation
Agricultural Division
McIntosh, Alabama (Caparol#)

2,2-Bis (p-methoxyphenyl) 1,1,1-trichloroethane (See: 1,1,1-Trichloro-2,2-bis [p-methoxyphenyl] ethane)

Bis (pentachloro-2,4-cyclopentadien-1-yl) (See: Decachlorobis [2,4-cyclopentadiene-1-yl)

Bis (tri-n-butyltin) oxide (Oxybis [tributyltin])
American Can Company
M&T Chemicals Inc., subsidiary
Carrollton, Kentucky (TBTO®)
Cincinnati Milacron Inc.
Cincinnati Milacron Chemicals Inc., subsidiary
Cincinnati, Ohio (Car-Ban®T-O Biostat)

Bomyl® (See: Dimethyl 3-hydroxyglutaconate dimethyl phosphate)

Borascu® (See: Sodium borates)

Borax® (See: Sodium borates)

Boro-spray® (See: Sodium borates)

Bramblcide® (See: [2,4,5-Trichlorophenoxy] acetic acid and iso-octyl ester)

Bromacil (See: 5-Bromo-3-sec-butyl-6-methyluracil)

Bromoacetyl bromide
Aldrich Chemical Company, Inc.
Milwaukee, Wisconsin

5-Bromo-3-sec-butyl-6-methyluracil (Bromacil) (Isocil)
E. I. du Pont de Nemours & Company, Inc.
Biochemicals Department
La Porte, Texas (Hyvar®)

O-(4-Bromo-2,5-dichlorophenyl)-O-methyl phenylphosphorothioate (Leptophos)
Northwest Industries, Inc.
Velsicol Chemical Corporation, subsidiary
Bayport, Texas

2-Bromo-4'-hydroxyacetophenone
Buckman Laboratories, Inc.
Cadet, Missouri
Memphis, Tennessee

Bromomethane (Methyl bromide)

		Annual Capacity (Millions of Pounds)
Dow Chemical U.S.A.		
Midland, Michigan		15.0
Great Lakes Chemical Corporation		
El Dorado, Arkansas		10.0
Kerr-McGee Corporation		
Kerr-McGee Chemical Corp., subsidiary		
Trona, California		1.3
Northwest Industries, Inc.		
Michigan Chemical Corporation, subsidiary		
St. Louis, Michigan	(Pestmaster#)	5.0
	TOTAL	31.3

Source: Chemical Marketing Reporter, September 18, 1972.

Bromoxynil (See: 3,5-Dibromo-4-hydroxybenzonitrile)

Bulan# (See: Dilan#)

Busan# (See: Cyanodithioimidocarbonic acid, sodium salt)

Butacide# (See: Piperonyl butoxide)

Butoxone# (See: 4-[2,4-Dichlorophenoxy] butyric acid)

#-(2-[2-n-Butoxyethoxy]-ethoxy)-4,5-methylenedioxy-2-propyltoluene (See: Piperonyl butoxide)

2-(2-Butoxyethoxy) ethyl thiocyanate (#-Butoxy-#-thiocyanodiethyl ether) (Thiocyanic acid, 2-[2-butoxyethoxy] ethyl ester)
  Blue Spruce Company
    Edison, New Jersey
  Rohm and Haas Company
    Bristol, Pennsylvania (Lethane#)

Butoxypolypropylene glycol
  Union Carbide Corporation
    Chemicals and Plastics Division
      Institute and South Charlest (Stabilene#)

#-Butoxy-#-thiocyanodiethyl ether (See: 2-[2-Butoxyethoxy] ethyl thiocyanate)

Butylate (See: S-Ethyl diisobutylthiocarbamate)

2-tert-Butylamino-4-ethylamino-6-methylthio-s-triazine
Ciba-Geigy Corporation
Agricultural Division
McIntosh, Alabama (Igran 80W®)

Butylcarbityl (6-propylpiperonyl) ether
(See: Piperonyl butoxide)

3-tert-Butyl-5-chloro-6-methyluracil (Terbacil)
E. I. du Pont de Nemours & Company, Inc.
Biochemicals Department
La Porte, Texas (Sinbar®)

O-(4-tert-Butyl-2-chlorophenyl) O-methyl methylphosphoramidate (Methylphosphoramidic acid, 4-tert-butyl-2-chlorophenyl methyl ester)
Dow Chemical U.S.A.
Midland, Michigan (Ruelene®)

2-sec-Butyl-4,6-dinitrophenol (Chem-ox) (Dinoseb) (DNBP) (DNOSBP) (4,6-Dinitro-o-sec-butylphenol) (4,6-Dinitrophenol-2-sec-butylphenol)
Blue Spruce Company
Edison, New Jersey
Dow Chemical U.S.A.
Midland, Michigan

2-sec-Butyl-4,6-dinitrophenol, alkanolamine salt
Dow Chemical U.S.A.
Midland, Michigan

2-sec-Butyl-4,6-dinitrophenol, ammonium salt
FMC Corporation
Chemical Group
Agricultural Chemical Division
Middleport, New York (Sinox® General)

2-sec-Butyl-4,6-dinitrophenol, isopropanolamine salt
Blue Spruce Company
Edison, New Jersey

2-sec-Butyl-4,6-dinitrophenol, triethanolamine salt
Blue Spruce Company
Edison, New Jersey
FMC Corporation
Chemical Group
Agricultural Chemical Division
Middleport, New York (Sinox®PE)

2-sec-Butyl-4,6-dinitrophenyl isopropyl carbonate
(See: Dinobuton)

N-Butyl-N-ethyl-#,#,#-trifluoro-2,6-dinitro-p-toluidine (Benefin)
Eli Lilly and Company
Tippecanoe Laboratories
Lafayette, Indiana (Balan#)

2-(p-tert-butylphenoxy) cyclohexyl propynl sulfite

2-Butynyl-4-chlorocarbanilate
(See: 4-Chloro-2-butynyl-m-chlorocarbanilate)

Butyrac# (See: 4-[2,4-Dichlorophenoxy] butyric acid)

BUX (Mixture of m[1-Methylbutyl] phenylmethylcarbamate [75%] and m[1-Ethylpropyl] phenylmethylcarbamate [25%])
Standard Oil Company of California
Chevron Chemical Company, subsidiary
Ortho Division
Fort Madison, Iowa (Bux Ten#)

CDAA (See: 2-Chloro-N,N-diallylacetamide)

CDEC (See: 2-Chloroallyl diethyldithiocarbamate)

CIPC (See: Isopropyl 3-chlorocarbanilate)

CMA (See: Methanearsonic acid, calcium and acid calcium salts)

CMU (See: 3-[p-Chlorophenyl]-1,1-dimethylurea)

4-CPA (See: p-Chlorophenoxyacetic acid)

Cacodylic acid (Dimethylarsinic acid) (Hydroxydimethylarsine oxide)
The Ansul Company
Chemical Division
Marinette, Wisconsin (Phytar# 560)

Cacodylic acid, sodium salt

Cadmium succinate
Mallinckrodt Chemical Works
Industrial Chemicals Division
St. Louis, Missouri

Calar# (See: Methanearsonic acid, calcium acid salt)

Calcium acid methyl arsonate (See: Methanearsonic acid, calcium acid salt)

Calcium arsenate
Chempar Chemical Co., Inc.
Portland, Oregon
Los Angeles Chemical Company
South Gate, California
Pennwalt Corporation
Chemical Division
Bryan, Texas

Calo-clor# (See: Mercury bichloride)

Calocure# (See: Mercury bichloride)

Cantrol (See: 4-[2-Methyl-4-chlorophenoxy] butyric acid)

Caparol# (See: 2,4-Bis [isopropylamino]-6-methylthio-s-triazine)

Captan (N-[Trichloromethylthio]-4-cyclohexene-1,2-dicarboximide) (N-Trichloromethylthiotetrahydrophthalimide) (n[Trichloromethylmercapto]-4-cyclohexene-1,2-dicarboximide)
Standard Oil Company of California
Chevron Chemical Company, subsidiary
Ortho Division
Perry, Ohio
Stauffer Chemical Company
Calhio Chemicals, Inc., subsidiary
Perry, Ohio

Car-Ban# T-O Biostat (See: Bis (tri-n-butyltin) oxide)

Carbaryl (See: 1-Naphthyl N-methylcarbamate)

Carbofuran (See: 2,3-Dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate)

2-Carbomethoxy-1-methylvinyl dimethyl phosphate, # isomer (See: 0,0-Dimethyl 0-[2-carbomethoxy-1-methylvinyl] phosphate)

Carbon bisulfide (See: Carbon disulfide)

Carbon disulfide

Carbon tetrachloride

Carbophenothion (See: O,O-Diethyl-S-p-chlorophenylthiomethyl phosphorodithioate)

2-Carboxymethoxy-1-methylvinyl dimethyl phosphate (See: O,O-Dimethyl O-[2-carbomethoxy-1-methylvinyl] phosphate)

Carbyne# (See: 4-Chloro-2-butynyl m-chlorocarbanilate)

Ceresan# (See: Ethylmercury chloride)

Ceresan#L (See: Granosan L)

Ceresan#M (See: N-[Ethylmercuri]-p-toluene sulfonanilide)

Chem-ox (See: 2-sec-Butyl-4,6-dinitrophenol)

Chem bam# (See: Ethylene bis [dithiocarbamic acid], disodium salt)

Chem rice# (See: 3',4'-Dichloropropionanilide)

Chlonitralid (See: 2',5-Dichloro-4'-nitrosalicylanilide, 2-aminoethanol salt)

Chlorambon (See: 3-Amino-2,5-dichlorobenzoic acid)

o-Chloranil (Tetrachloro-p-benzoquinone) (Tetrachloroquinone)
  Syntex Corporation
    Arapahoe Chemicals Division
      Boulder, Colorado

Chlorazine (2-Chloro-4,6-bis [diethylamino]-s-triazine)
  Ciba-Geigy Corporation
    Agricultural Division
      McIntosh, Alabama (Princep#80W)

Chlordane (1,2,4,5,6,7,8,8-Octachloro-3#,4,7,7#-tetrahydro-4,7-methanoindan) (Octachlorohexahydromethanoindene)
  Northwest Industries, Inc.
    Velsicol Chemical Corporation, subsidiary
      Marshall, Illinois
  Prentiss Drug & Chemical Co., Inc.
      Newark, New Jersey

Chlorinated camphene (See: Toxaphene)

Chlorobenzilate (See: Ethyl 4,4'-dichlorobenzilate)

5-Chloro-2-benzothiazolethiol, laurylpyridinium salt (See: 5-Chloro-2-mercaptobenzothiazole, laurylpyridinium salt)

2-Chloro-4,6-bis (diethylamino)-s-triazine (See: Chlorazine)

2-Chloro-4,6-bis (ethylamino)-s-triazine (See: Simazine)

2-Chloro-4,6-bis (isopropylamino)-s-triazine (2,4-Bis [isopropylamino]-6-chloro-s-triazine) (Propazine)
Ciba-Geigy Corporation
Agricultural Division
McIntosh, Alabama (Milogard®)

5-Chloro-3-tert-butyl-6-methyluracil (See: 3-tert-Butyl-5-chloro-6-methyluracil)

4-Chloro-2-butynyl m-chlorocarbanilate (Barban)
(4-Chloro-2-butynyl N-[3-chlorophenyl] carbamate)
(m-Chlorocarbanilic acid, 4-chloro-2-butynyl ester)
Gulf Oil Corporation
Gulf Oil Chemicals Company, division
Industrial and Specialty Chemicals Division
Pittsburg, Kansas (Carbyne®)

3-Chlorocarbanilic acid, isopropyl ester (See: Isopropyl 3-chlorocarbanilate)

2-Chloro-N,N-diallylacetamide (CDAA) (N,N-Diallyl-2-chloroacetamide)
Monsanto Company
Monsanto Commercial Products Company
Agricultural Division
Muscatine, Iowa (Randox®)

O-(2-Chloro-1-[2,5-dichlorophenyl] vinyl) O,O-diethyl phosphorothioate (See: O,O-Diethyl O-[2-chloro-1-(2,5-dichlorophenyl) vinyl] phosphorothioate)

2-Chloro-2-diethylcarbamoyl-1-methylvinyl dimethyl phosphate (See: Phosphamidon)

2-Chloro-2,6'-diethyl-N-butoxymethyl acetanilide
Monsanto Company
Monsanto Commercial Products Company
Agricultural Division

Muscatine, Iowa

2-Chloro-2,6'-diethyl-N-(methoxymethyl) acetanilide
Monsanto Company
Monsanto Commercial Products Company
Agricultural Division
Muscatine, Iowa (Lasso®)
St. Louis, Missouri

2-Chloro-4-ethylamino-6-isopropylamino-triazine (Atrazine)
Ciba-Geigy Corporation
Agricultural Division
McIntosh, Alabama (AAtrex®)
(Atratol®)
St. Gabriel, Louisiana

2-(4-Chloro-6-ethylamino-s-triazin-2-ylamino)-2-methylpropionitrile
Shell Chemical Company
Agricultural Division
Denver, Colorado (Bladex®)

Chloroethylmercury (See: Ethylmercury chloride)

2-Chloroethyl phosphonic acid (Ethrel®)
Borer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania (Ethrel®)

2-Chloroethyltrimethyl ammonium chloride
American Cyanamid Company
Agricultural Division
Linden, New Jersey (Cycocel®)

Chlorofenson (See: p-Chlorophenyl p-chlorobenzenesulfonate)

Chloro IPC (See: Isopropyl-3-chlorocarbanilate)

2-Chloro-N-isopropyl acetanilide (Propachlor)
Monsanto Company
Monsanto Commercial Products Company
Agricultural Division
Muscatine, Iowa (Ramrod®)

Chloromethoxypropylmercuric acetate
Troy Chemical Corporation
Newark, New Jersey

O-(3-Chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl) O,O,-diethylphosphorothioate (See: O,O-

Diethyl O-[n-chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl] phosphorothioate)

4-Chloro-2-methylphenoxyacetic acid (See: [4-Chloro-o-tolyloxy] acetic acid)

Chloroneb (See: 1,4-Dichloro-2,5-dimethoxybenzene)

O-2-Chloro-4-nitrophenyl O,O-diethyl phosphorothioate (Dicapthon)
American Cyanamid Company
Agricultural Division
Linden, New Jersey

Chlorophacinone
Chempar Chemical Co., Inc.
Ancramdale, New York ("RoZol")

Chlorophenothane (See: DDT)

p-Chlorophenoxyacetic acid (4-CPA) (Fruitone)
Abbott Laboratories
Agricultural/Veterinary Products Division
North Chicago, Illinois

N'-(4-Chlorophenoxy) phenyl N,N-dimethylurea (Chloroxuron)
Ciba-Geigy Corporation
Agricultural Division
McIntosh, Alabama (Tenoran®)
Nor-Am Agricultural Products, Inc.
Chicago, Illinois (Tenoran®)

p-Chlorophenyl p-chlorobenzenesulfonate (p-Chlorobenzenesulfonic acid, p-chlorophenyl ester) (Chlorofenson) (Ovex)
Diamond Shamrock Corporation
Diamond Shamrock Chemical Company
Agricultural Division
Greens Bayou, Texas

4-Chloro-α-phenyl-o-cresol (See: o-Benzyl-p-chlorophenol)

p-Chlorophenyl diiodomethyl sulfone
Abbott Laboratories
Chemical Division
North Chicago, Illinois

3-(p-Chlorophenyl)-1,1-dimethylurea (CMU) (Monuron)
E. I. du Pont de Nemours & Company, Inc.
Biochemicals Department

La Porte, Texas (Telvar®)

3-(p-Chlorophenyl)-1,1-dimethylurea trichloroacetate (Monuron TCA)
Allied Chemical Corporation
Union Texas Petroleum Division
Agricultural Department
Baltimore, Maryland (Urox®)

Chlorophenylmercury (See: Phenylmercury chloride)

2-([p-Chlorophenyl]phenyl acetyl)-1,3-indandione (See: Chlorophacinone)

S-([(p-Chlorophenyl) thio] methyl) O,O-dimethyl phosphorodithioate (See: O,O-Dimethyl S-[p-chlorophenylthio] methyl phosphorodithioate)

S-(p-Chlorophenylthio) methyl O,O-diethyl phosphorodithioate (See: O,O-Diethyl S-[p-chlorophenylthiomethyl] phosphorodithioate)

Chloropicrin (Nitrochloroform) (Trichloronitromethane)
Dow Chemical U.S.A.
Pittsburg, California
Great Lakes Chemical Corporation
El Dorado, Arkansas (Chlor-O-Pic®)
Niklor Chemical Company, Inc.
Long Beach, California
Sobin Chemicals, Inc.
Orrington, Maine

Chloropropylate® (See: Isopropyl 4,4'-dichlorobenzilate)

(4-Chloro-o-tolyloxy) acetic acid (MCP) (MCPA) (2-Methyl-4-chlorophenoxyacetic acid) (4-Chloro-2-methylphenoxyacetic acid)
Rhodia Inc.
Chipman Division
Portland, Oregon
Transvaal, Inc.
Jacksonville, Arkansas

(4-Chloro-o-tolyloxy) acetic acid, salts (unspecified)
Rhodia Inc.
Chipman Division
Portland, Oregon

2-Chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl phosphate (See: Dimethyl-1-[2,4,5-trichlorophenyl]-2-chlorovinyl phosphate)

Chloroxuron (See: N'-[4-Chlorophenoxy] phenyl-N,N-dimethylurea)

Chlorphenamidine (See: N,N-Dimethyl-N'-[2-methyl-4-chlorophenyl]-formamidine)

Chlorphos (See: O,O-Dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate)

Chlorpropham (See: Isopropyl-3-chlorobanilate)

Ciodrin® (See: O,O-Dimethyl O-[1-methyl-2-(1-phenylcarbethoxy) vinyl] phosphate)

Copper acetate (Cupric acetate)
Allied Chemical Corporation
Specialty Chemicals Division
Marcus Hook, Pennsylvania
Chemetron Corporation
Chemicals Group
Inorganic Chemicals Division
Cleveland, Ohio
C. P. Chemicals, Inc.
Sewaren, New Jersey
Filo Color and Chemical Corporation
Newark, New Jersey
Mineral Research and Development Corp.
Concord, North Carolina
Richardson-Merrell, Inc.
J. T. Baker Chemical Co., subsidiary
Phillipsburg, New Jersey
The Shepherd Chemical Company
Cincinnati, Ohio
Union Carbide Corporation
Chemicals and Plastics Division
Niagara Falls, New York

Copper acetoarsenite

Copper carbonate

Copper-8-hydroxyquinolinate (See: 8-Quinolinol, copper salt)

Copper naphthenate (Cupric naphthenate)
Chemical Formulators, Inc.
Chemical Division
Nitro, West Virginia
Cincinnati Milacron Inc.
Cincinnati Milacron Chemicals Inc., subsidiary
New Brunswick, New Jersey
Ferro Corporation

Ferro Chemical Division
Bedford, Ohio
Mobil Oil Corporation
North American Division
Torrance, California
Mooney Chemicals, Inc.
Franklin, Pennsylvania
The Shepherd Chemical Company
Cincinnati, Ohio
Tenneco Inc.
Tenneco Chemicals, Inc.
Intermediates Division
Elizabeth, New Jersey
Long Beach, California
Triangle Chemical Company
Macon, Georgia
Troy Chemical Corporation
Newark, New Jersey

Copper oleate

Copper oxinate (See: 8-Quinolinol, copper salt)

Copper oxychloride sulfate

Copper-8-quinolinolate (See: 8-Quinolinol, copper salt)

Copper sulfate

Copper-zinc chromate complex
Alco Standard Corporation
Miller Chemical and Fertilizer Corporation, subsidiary
Hanover, Pennsylvania (Miller 658 Fungicide)

Co-ral® (See: O,O-Diethyl O-[3-chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl] phosphorothioate)

Cotoran® (See: 1,1-Dimethyl-3-[α,α,α-trifluoro-m-tolyl] urea)

Coumafene (See: Warfarin)

Coumafuryl (See: 3-[1-Furyl-3-acetylethyl]-4-hydroxycoumarin)

Coumaphos (See: O,O-Diethyl O-[3-chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl] phosphorothioate)

Crag® Turf Fungicide 531 (See: Cadmium-calcium-copper-zinc chromate complex)

Cyanodithioimidocarbonic acid, disodium salt (Pusan®)

Buckman Laboratories, Inc.
Cadet, Missouri
Memphis, Tennessee

Cyclic ethylene (diethoxyphosphinyl) dithioimidocarbonate
American Cyanamid Company
Agricultural Division
Linden, New Jersey (Cyolane®)

Cycloate (See: S-Ethyl N-ethyl-N-cyclohexylthiocarbamate)

Cycocel® (See: 2-Chloroethyltrimethyl ammonium chloride)

Cygon® (See: O,O-Dimethyl S-[N-methylcarbamoylmethyl] phosphorodithioate)

Cyolane® (See: Cyclic ethylene [diethoxyphosphinyl] dithioimidocarbonate)

Cyprex® (See: Dodecylguanidine acetate)

2,4-D (See: [2,4-Dichlorophenoxy] acetic acid)

2,4-DB (See: 4-[2,4-Dichlorophenoxy] butyric acid)

4-(2,4-DB) (See: 4-[2,4-Dichlorophenoxy] butyric acid)

DBCP (See: 1,2-Dibromo-3-chloropropane)

DCMU (See: 3-[3,4-Dichlorophenyl]-1,1-dimethylurea)

DCNA (See: 2,6-Dichloro-4-nitroaniline)

DCPA (See: Dimethyl tetrachloroterephthalate)

DCU (See: 1,3-Bis [1-hydroxy-2,2,2-trichloroethyl] urea)

DD mixture (See: 1,3-Dichloropropene, 1,2-dichloropropane)

DDT (1,1,1-Trichloro-2,2-bis [p-chlorophenyl] ethane) (Chlorophenothane) (α,α-Bis [p-chlorophenyl] β,β,β-trichloroethane) (Dichlorodiphenyltrichloroethane)

	Annual Capacity (Millions of Pounds)
Montrose Chemical Corporation of California Torrance, California	85
TOTAL	85

Note: Not currently producing.

Sources: Oil, Paint and Drug Reporter, January 4, 1971, and correspondence.

DDVP (See: 2,2-Dichlorovinyl dimethyl phosphate)

DET (See: N,N-Diethyl-m-toluamide)

DHA (See: Dehydroacetic acid)

DMDT (See: 1,1,1-Trichloro-2,2-bis [p-methoxyphenyl] ethane)

DMP (See: Dimethyl phthalate under Plasticizers)

DMTT (See: 3,5-Dimethyl-1,3,5,2H-tetrahydrothiadiazine-2-thione)

DMU (See: 3-[3,4-Dichlorophenyl]-1,1-dimethylurea)

DNBP (See: 2-sec-Butyl-4,6-dinitrophenol)

DNC (See: 4,6-Dinitro-o-cresol)

DNOSBP (See: 2-sec-Butyl-4,6-dinitrophenol)

2,4-DP (See: 2-[2,4-Dichlorophenoxy] propionic acid)

DSMA (See: Methanearsonic acid, disodium salt)

Dacamine® (See: [2,4-Dichlorophenoxy] acetic acid, oil soluble diamine)

Dacthal® (See: Dimethyl tetrachloroterephthalate)

Dalapon® (See: 2,2-Dichloropropionic acid, sodium salt)

Dasanit® (See: 0,0,-Diethyl O-p-[methylsulfinyl] phenyl phosphorothioate)

Dazomet (See: 3,5-Dimethyl-1,3,5,2H-tetrahydrothiadiazine-2-thione)

Decachlorobis (2,4-cyclopentadiene-1-yl)
(Bis [pentachloro-2,4-cyclopentadien-1-yl])
  Occidental Petroleum Corporation
    Hooker Chemical Corporation, subsidiary
      Electrochemical and Specialties Divisions
        Niagara Falls, New York (Pentac TM®)

Decachloro-octahydro-1,3,4-metheno-2H-cyclobuta [CD] pentalene-2-one
  Allied Chemical Corporation
    Plastics Division
        Hopewell, Virginia

Dechlorane (See: Dodecachloro-octahydro-1,3,4-metheno-2H-cyclobuta [cd] pentalene)

DEET (See: N,N-Diethyl-m-toluamide)

DEF® (See: S,S,S-Tributyl phosphorotrithioate)

Dehydroacetic acid

Delnav® (See: p-Dioxane-2,3-diyl ethyl phosphorodithioate)

Demeton (See: 0,0-Diethyl O [and S]-2-[ethylthio] ethyl phosphorothioates)

Demeton-S-methyl (See: 0,0-Dimethyl S-2-[ethylsulfinyl] ethyl phosphorodithioate)

Demosan® 65W (See: 1,4-Dichloro-2,5-dimethoxybenzene)

Dossin® (See: Dinobuton)

Dethmor® (See: Warfarin)

Doxon® (See: p-Dimethylaminobenzenediazosulfonic acid, sodium salt)

N,N-Diallyl-2-chloroacetamide (See: 2-Chloro-N,N-diallylacetamide)

Diazinon® (See: 0,0-Diethyl O-[2-isopropyl-4-

methyl-6-pyrimidinyl] phosphorothioate)

Dibenzo 1,4-thiazine (See: Phenothiazine)

1,2-Dibromo-3-chloropropane (DBCP)
Dow Chemical U.S.A.
Midland, Michigan
Shell Chemical Company
Agricultural Division
Denver, Colorado (Nemagon®)

1,2-Dibromo-2,2-dichloroethyl dimethyl phosphate
(See: O,O-Dimethyl O-[1,2-dibromo-2,2-dichloroethyl]
phosphate)

1,2-Dibromoethane (See: Ethylene dibromide)

3,5-Dibromo-4-hydroxybenzonitrile (Bromoxynil)
Rhodia Inc.
Chipman Division
Portland, Oregon

Di-n-butyl succinate
Glenn Chemical Company, Inc.
Chicago, Illinois (Tabatrex®)

Dicamba (See: 3,6-Dichloro-o-anisic acid)

Dicapthon (See: O-2-Chloro-4-nitrophenyl O,O-diethyl phosphorothioate)

S-(1,2-Dicarbethoxyethyl)-O,O-dimethyl
dithiophosphate (See: Malathion)

Dichlone (2,3-Dichloro-1,4-naphthoquinone)
FMC Corporation
Chemical Group
Agricultural Chemical Division
Middleport, New York

2,5-Dichloro-3-aminobenzoic acid, ammonium salt
(See: 3-Amino-2,5-dichlorobenzoic acid, ammonium salt)

3,6-Dichloro-o-anisic acid (Dicamba)
Northwest Industries, Inc.
Velsicol Chemical Corporation, subsidiary
Chattanooga, Tennessee (Banvel®D)
PBI-Gordon Corporation
Kansas City, Kansas (Trimec®)

p-Dichlorobenzene

	Annual Capacity (Millions of Pounds)	Remarks
Allied Chemical Corporation		
Industrial Chemicals Division		
Syracuse (Solvay), New York	12	Producer
Chemical Products Corporation		
Cartersville, Georgia	3	Processor
Dow Chemical U.S.A.		
Midland, Michigan	16	Producer
Monsanto Company		
Monsanto Industrial Chemicals Company		
Sauget, Illinois	12	Producer
PPG Industries, Inc.		
Chemical Division		
Industrial Chemical Division		
Natrium, West Virginia	21	Producer
Solvent Chemical Company, Inc.		
Malden, Massachusetts	5	Producer; production at Malden will be phased out by late 1974.
Niagara Falls, New York	*20	Producer
Specialty Organics, Inc.		
Irwindale, California	2	Processor
Standard Chlorine Chemical Co., Inc.		
Delaware City, Delaware	60	Producer
TOTAL	151	

*Includes capacity for o-dichlorobenzene and 1,2,4-trichlorobenzene.

Source: Chemical Marketing Reporter, April 9, 1973.

o- (and p)-Dichlorobenzene
Montrose Chemical Corporation of California
Henderson, Nevada

4,4'-Dichlorobenzilic acid, ethyl ester (See: Ethyl 4,4'-dichlorobenzilate)

2,4-Dichlorobenzyltributylphosphonium chloride (See: Tributyl [2,4-dichlorobenzyl] phosphonium chloride)

1,1-Dichloro-2,2-bis (p-ethylphenyl) ethane (Diethyl-diphenyl-dichloroethane)
Rohm and Haas Company
Philadelphia, Pennsylvania (Perthane®)

2,4-Dichloro-6-(o-chloroaniline)-s-triazine
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (Dyrene®)

1,4-Dichloro-2,5-dimethoxybenzene (Chloroneb)
E. I. du Pont de Nemours & Company, Inc.
Industrial Chemicals Department
Linden, New Jersey (Demosan® 65W)

3,5-Dichloro-N-(1,1-dimethyl-2-propanyl) benzamide
Rohm and Haas Company
Philadelphia, Pennsylvania

Dichlorodiphenyltrichloroethane (See: DDT)

1,2-Dichloroethane (See: Ethylene dichloride in general alphabetical listing)

2,3-Dichloro-1,4-naphthoquinone (See: Dichlone)

2,6-Dichloro-4-nitroaniline (1-Amino-2,6-dichloro-4-nitrobenzene)
GAF Corporation
Chemical Division
Rensselaer, New York
Kewanee Oil Company
Harshaw Chemical Company, division
Pigment and Ceramic Department
Louisville, Kentucky
The Sherwin-Williams Co.
Sherwin-Williams Chemicals Division
St. Bernard, Ohio

Dichloronitrobenzoic acid, isometric mixture
GAF Corporation
Chemical Division
Linden, New Jersey

2',5-Dichloro-4'-nitrosalicylanilide (Yomesan®)
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (Yomesan®)

2',5-Dichloro-4'-nitrosalicylanilide, 2-aminoethanol salt (2'-5-Dichloro-4'-nitrosalicylanilide ethanolamine) (Chlonitralid) (Yomesan)
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (Bayluscide®)

2,4-Dichlorophenol, benzenesulfonate (See: 2,4-

Dichlorophenyl benzenesulfonate)

(2,4-Dichlorophenoxy)acetic acid (2,4-D)
Dow Chemical U.S.A.
Midland, Michigan
Rhodia Inc.
Chipman Division
Portland, Oregon
Transvaal, Inc.
Jacksonville, Arkansas

(2,4-Dichlorophenoxy)acetic acid, n-butoxyethyl ester
Dow Chemical U.S.A.
Midland, Michigan
Riverdale Chemical Company
Chicago Heights, Illinois
Rorer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania

(2,4-Dichlorophenoxy)acetic acid, butoxypolypropyleneglycol ester
Dow Chemical U.S.A.
Midland, Michigan

(2,4-Dichlorophenoxy)acetic acid, butoxy propyl ester
Dow Chemical U.S.A.
Midland, Michigan

(2,4-Dichlorophenoxy)acetic acid, n-butyl ester
Chempar Chemical Co., Inc.
Portland, Oregon
Imperial, Inc.
Shenandoah, Iowa
North American Philips Corp.
PEPI, Inc., subsidiary
Thompson-Hayward Chemical Company, subsidiary
Kansas City, Kansas
PBI-Gordon Corporation
Kansas City, Kansas
Rhodia Inc.
Chipman Division
Portland, Oregon
Riverdale Chemical Company
Chicago Heights, Illinois
Rorer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania
Fremont, California
St. Joseph, Missouri
Transvaal, Inc.
Jacksonville, Arkansas

(2,4-Dichlorophenoxy)acetic acid, sec-butyl ester
  Dow Chemical U.S.A.
      Midland, Michigan
  Rhodia Inc.
    Chipman Division
      Portland, Oregon

(2,4-Dichlorophenoxy)acetic acid, dimethylamine salt
  Alco Standard Corporation
    Miller Chemical and Fertilizer Corporation, subsidiary
      Hanover, Pennsylvania
  Chempar Chemical Co., Inc.
      Portland, Oregon
  Dow Chemical U.S.A.
      Midland, Michigan
  North American Philips Corp.
    PEPI, Inc., subsidiary
      Thompson-Hayward Chemical Company, subsidiary
      Kansas City, Kansas
      New Orleans, Louisiana
  PBI-Gordon Corporation
      Kansas City, Kansas
  Rhodia Inc.
    Chipman Division
      Portland, Oregon
  Riverdale Chemical Company
      Chicago Heights, Illinois
  Rorer-Amchem
    Amchem Products, Inc., division
      Ambler, Pennsylvania
      Fremont, California
      St. Joseph, Missouri
  Transvaal, Inc.
      Jacksonville, Arkansas

(2,4-Dichlorophenoxy)acetic acid, N,N-dimethyl oleyl/linoleyl amine salt
  Transvaal, Inc.
      Jacksonville, Arkansas

(2,4-Dichlorophenoxy)acetic acid, ethanolamine and isopropanolamine salts
  Dow Chemical U.S.A.
      Midland, Michigan

(2,4-Dichlorophenoxy)acetic acid, ethyl ester
  Rorer-Amchem
    Amchem Products, Inc., division
      Ambler, Pennsylvania
      Fremont, California
      St. Joseph, Missouri

(2,4-Dichlorophenoxy)acetic acid, 2-ethylhexyl ester (See: [2,4-Dichlorophenoxy] acetic acid, iso-octyl ester)

(2,4-Dichlorophenoxy)acetic acid, iso-octyl ester
([2,4-Dichlorophenoxy]-acetic acid, 2-ethylhexyl ester)
Chempar Chemical Co., Inc.
Portland, Oregon
Dow Chemical U.S.A.
Midland, Michigan
North American Philips Corp.
PEPI, Inc., subsidiary
Thompson-Hayward Chemical Company, subsidiary
Kansas City, Kansas
PBI-Gordon Corporation
Kansas City, Kansas
Rhodia Inc.
Chipman Division
Portland, Oregon
Riverdale Chemical Company
Chicago Heights, Illinois
Rorer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania
Fremont, California
St. Joseph, Missouri
Transvaal, Inc.
Jacksonville, Arkansas

(2,4-Dichlorophenoxy)acetic acid, isopropyl ester
Chempar Chemical Co., Inc.
Portland, Oregon
Dow Chemical U.S.A.
Midland, Michigan
Riverdale Chemical Company
Chicago Heights, Illinois
Transvaal, Inc.
Jacksonville, Arkansas

(2,4-Dichlorophenoxy)acetic acid, sodium salt
Alco Standard Corporation
Miller Chemical and Fertilizer Corporation, subsidiary
Hanover, Pennsylvania
Dow Chemical U.S.A.
Midland, Michigan
Riverdale Chemical Company
Chicago Heights, Illinois

4-(2,4-Dichlorophenoxy) butyric acid (4-[2,4-DB])
(2,4-DB)
Rhodia Inc.
Chipman Division

Portland, Oregon (Butoxone#)
Rorer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania (Butyrac#)

2-(2,4-Dichlorophenoxy) ethanol sulfate, sodium salt (2,4-Dichlorophenoxyethylsulfate, sodium salt) (2,4-DES) (Disul-sodium)
GAF Corporation
Chemical Division
Linden, New Jersey (Crag herbicide 1#)

2-(2,4-Dichlorophenoxy) propionic acid
Transvaal, Inc.
Jacksonville, Arkansas

O-2,4-Dichlorophenyl O,O-diethyl phosphorothioate (O,O-Diethyl O-[2,4-dichlorophenyl] phosphorothioate) (Nemacide)
Mobil Oil Corporation
Mobil Chemical Company, division
Industrial Chemicals Division
Charleston, South Carolina (V-C13#)

3-(3,4-Dichlorophenyl)-1,1-dimethylurea (DCMU) (Diuron) (DMU)
E. I. du Pont de Nemours & Company, Inc.
Biochemicals Department
La Porte, Texas (Karmex#)

3-(3,4-Dichlorophenyl)-1-methoxy-1-methylurea (Afalon) (Linuron)
E. I. du Pont de Nemours & Company, Inc.
Biochemicals Department
La Porte, Texas
Industrial Chemicals Department
East Chicago, Indiana (Lorax#)

2,4-Dichlorophenyl-4-nitrophenyl ether (Nitrofen) (NIP)
Rohm and Haas Company
Philadelphia, Pennsylvania (Tok#)

1,3-Dichloropropene
Dow Chemical U.S.A.
Freeport, Texas (Telone#)

1,3-Dichloropropene, 1,2-dichloropropane mixture (Telone) (Vidden D)
Dow Chemical U.S.A.
Freeport, Texas (Dowfume#NC)
Shell Chemical Company

Industrial Chemicals Division
Deer Park, Texas (D-D®)
Norco, Louisiana

3,4-Dichloropropionanilide (Propanil)
Blue Spruce Company
Edison, New Jersey
Rohm and Haas Company
Philadelphia, Pennsylvania (Stam®)
Sobin Chemicals, Inc.
Montrose Chemical Division
Newark, New Jersey

2,2-Dichloropropionic acid, sodium salt
Dow Chemical U.S.A.
Midland, Michigan (Dalapon®)

4,4'-Dichloro-α-(trichloromethyl) benzhydrol
(Dicofol) (1,1-Bis [p-chlorophenyl]-2,2,2-
trichloroethanol)
Rohm and Haas Company
Philadelphia, Pennsylvania (Kelthane®)

2,2-Dichlorovinyl dimethyl phosphate (DDVP)
(Dichlorvos) (0,0-Dimethyl-O-2,2-dichlorovinyl phosphate)
Shell Chemical Company
Agricultural Division
Denver, Colorado (Vapona®)
Mobile, Alabama

Dicofol (See: 4,4'-Dichloro-α-[trichloromethyl]
benzhydrol)

O,O-Diethyl O-(2-chloro-1-[2,5-dichlorophenyl]
vinyl) phosphorothioate (O-[2-Chloro-1-(2,5-
dichlorophenyl) vinyl] O,O-diethyl phosphorothioate)
Shell Chemical Company
Agricultural Division
Denver, Colorado (Akton®)

O,O-Diethyl O-(3-chloro-4-methyl-2-oxo-2H-1-benzopyran-7-yl) phosphorothioate (Coumaphos)
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (Co-ral®)

O,O-Diethyl S-(p-chlorophenylthiomethyl)
phosphorodithioate (S-[p-Chlorophenylthio] methyl
O,O-diethyl phosphorodithioate) (Carbophenothion)
Stauffer Chemical Company
Agricultural Chemical Division

Cold Creek, Alabama (Trithion#)

O,O-Diethyl O-(2,4-dichlorophenyl) phosphorothioate (See: O-2,4-Dichlorophenyl O,O-diethyl phosphorothioate)

Diethyl-diphenyl-dichloroethane (See: 1,1-Dichloro-2,2-bis [p-ethylphenyl] ethane)

Diethyl dithiobis (thionoformate) (Dexide) (EXD) (Tridex)
Pike Chemicals, Inc.
Nitro, West Virginia (Herbisan#)

O,O-Diethyl S-(2-[ethylthio] ethyl) phosphorodithioate (Disulfoton) (Dithiodemeton) (Dithiosystox) (Thiodemeton)
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (Disyston#)

O,O-Diethyl O- (and S)-(2-[ethylthio] ethyl phosphorothioates (Demeton) (Mercaptophos)
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (Systox#)

O,O-Diethyl S-([ethylthio] methyl) phosphorodithioate (Phorate)
American Cyanamid Company
Agricultural Division
Linden, New Jersey (Thimet#)

O,O-Diethyl O-(2-isopropyl-4-methyl-6-pyrimidinyl) phosphorothioate
Ciba-Geigy Corporation
Agricultural Division
McIntosh, Alabama (Diazinon#)
Prentiss Drug & Chemical Co., Inc.
Newark, New Jersey (Diazinon#)

O,O-Diethyl O-p-(methylsulfinyl) phenyl phosphorothioate (Fensulfothion)
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (Dasanit#)

O,O-Diethyl O-(p-nitrophenyl) phosphorothioate (O,O-Diethyl O-p-nitrophenyl thionophosphate) (Ethyl parathion) (Folidol) (Orthophos) (Parathion)
(See also: O,O-Dimethyl O-[p-nitrophenyl]phosphorothioate)
Monsanto Company

Monsanto Commercial Products Company
Agricultural Division
Anniston, Alabama (Niran®)
Stauffer Chemical Company
Agricultural Chemical Division
Mt. Pleasant, Tennessee

O,O-Diethyl O-(2-pyrazinyl) phosphorothioate (Thionazin)
American Cyanamid Company
Agricultural Division
Linden, New Jersey (Zinophos®)

N,N-Diethyl-m-toluamide (DET) (DEET)
Chemical Formulators, Inc.
Chemical Division
Nitro, West Virginia
Hercules Incorporated
Synthetics Department
Brunswick, Georgia (Metadelphene®)
McLaughlin Gormley King Company
Minneapolis, Minnesota
Pfizer Inc.
Chemicals Division
Greensboro, North Carolina

O,O-Diethyl-O-(3,5,6-trichloro-2-pyridyl) phosphorothioate
Dow Chemical U.S.A.
Midland, Michigan

Difolatan® (See: cis-N-[(1,1,2,2-Tetrachloroethyl) thio]-4-cyclohexene-1,2-dicarboximide)

2,3-Dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate (Carbofuran)
FMC Corporation
Chemical Group
Agricultural Chemical Division
Middleport, New York (Furadan®)
Industrial Chemical Division
Vancouver, Washington

(Dihydrogen borato) phenylmercury (See: Phenylmercury borate)

1,2-Dihydro-3,6-pyridazinedione (See: Maleic hydrazide)

3,5-Diiodo-4-hydroxybenzonitrile (See: Ioxynil)

N-(β-O,O-Diisopropyldithiophosphorylethyl)-

benzene sulfonamide (N-[2-Mercaptoethyl]
benzenesulfonamide, S-[O,O-diisopropyl phosphoro-
dithioate] ester) (Bensulide)
Stauffer Chemical Company
Agricultural Chemical Division
Cold Creek, Alabama (Betasan#)
(Prefar#)

S-(O,O-Diisopropyl phosphorodithioate) ester
of N-(2-Mercaptoethyl) benzenesulfonamide
(See: N-[#-O,O-Diisopropyldithiophosphoryl-
ethyl]-benzene sulfonamide)

Dilan# (See: Mixture containing
2-Nitro-1,1-bis [p-chlorophenyl] butane [42.7%],
2-Nitro-1,1-bis [p-chlorophenyl] propane [21.3%]
and 16% related compounds in 20% xylene)

Dimecron (See: Phosphamidon)

Dimethoate (See: O,O-Dimethyl S-[N-methylcarbamoyl-
methyl] phosphorodithioate)

3-(Dimethoxyphosphinyloxy)-N,N-dimethyl-cis-
crotonamide (Dimethyl phosphate of 3-hydroxy-N,N-
dimethyl-cis-crotonamide) (3-Hydroxy-N,N-dimethyl-cis-
crotonamide-dimethyl phosphate)
Shell Chemical Company
Agricultural Division
Denver, Colorado (Bidrin#)

p-Dimethylaminobenzenediazosulfonic acid, sodium
salt (p-Dimethylamino benzene diazosodium sulfonate)
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (Dexon#)

m-[[(Dimethylamino)methylene]amino]phenyl
methylcarbamate hydrochloride (Formetanate hydrochoride)
Nor-Am Agricultural Products, Inc.
Chicago, Illinois (Carzol#)

N-Dimethylamino succinamic acid (Succinic
acid 2,2-dimethylhydrazide)

4-Dimethylamino-3,5-xylyl methylcarbamate
Dow Chemical U.S.A.
Midland, Michigan

Dimethyl arsinic acid (See: Cacodylic acid)

O,O-Dimethyl O-(2-carbomethoxy-1-methylvinyl)

phosphate (2-Carboxymethoxy-1-methylvinyl dimethyl phosphate) (3-Hydroxycrotonic acid, methyl ester, dimethyl phosphate) (Methyl 3-[dimethoxyphosphinyloxy] crotonate) (Mevinphos)
  Shell Chemical Company
    Agricultural Division
      Denver, Colorado (Phosdrin®)

O,O-Dimethyl S-(p-chlorophenylthio) methyl phosphorodithioate
  Stauffer Chemical Company
    Agricultural Chemical Division
      Cold Creek, Alabama (Methyl trithion®)

O,O-Dimethyl O-(1,2-dibromo-2,2-dichloroethyl) phosphate (Naled) (1,2-Dibromo-2,2-dichloroethyl dimethyl phosphate)
  Standard Oil Company of California
    Chevron Chemical Company, subsidiary
      Ortho Division
        Maryland Heights, Missouri
        Orlando, Florida
        Richmond, California
        South Plainfield, New Jersey

O,O-Dimethyl-O-2,2-dichlorovinyl phosphate (See: 2,2-Dichlorovinyl dimethyl phosphate)

O,O-Dimethyl O-p-(dimethylsulfamoyl) phenyl phosphorothioate (Famphur)
  American Cyanamid Company
    Agricultural Division
      Linden, New Jersey (Warbex®)

Dimethyldithiocarbamic acid, ferric salt (Ferbam) (Ferric dimethyldithiocarbamate)
  FMC Corporation
    Chemical Group
      Agricultural Chemical Division
        Middleport, New York

Dimethyldithiocarbamic acid, potassium salt

Dimethyldithiocarbamic acid, sodium salt

Dimethyldithiocarbamic acid, zinc salt

O,O-Dimethyl S-2-(ethylsulfinyl) ethyl phosphorodithioate (Oxydemetonmethyl) (S-2-[Ethylsulfinyl]

ethyl O,O-methyl phosphorodithioate) (Demeton-S-methyl) (Methyl-demeton) (O-[2-(Ethylthio) ethyl] O,O-dimethyl phosphorothioate)
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (Meta-Systox#)

O,O-Dimethyl-(1-hydroxy-2,2,2-trichloroethyl) phosphonate (See: O,O-Dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate)

O,O-Dimethyl S-(N-methylcarbamoylmethyl) phosphorodithioate (Dimethoate)
American Cyanamid Company
Agricultural Division
Linden, New Jersey (Cygon#)

N,N-Dimethyl-N'-(2-methyl-4-chlorophenyl)-formamidine (Chlorphenamidine) (Fundal)
Ciba-Geigy Corporation
Agricultural Division
McIntosh, Alabama
Nor-Am Agricultural Products, Inc.
Chicago, Illinois (Fundal#)

O,O-Dimethyl O-(1-methyl-2-[1-phenylcarbethoxy] vinyl) phosphate (Dimethyl phosphate of #-Methylbenzyl-3-hydroxy-cis-crotonate)
Shell Chemical Company
Agricultural Division
Denver, Colorado (Ciodrin#)

O,O-Dimethyl O-(4-[methylthio]-m-tolyl) phosphorothioate (Fenthion) (Lebaycid)
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (Baytex#)
(Entex#)
(Tiguvon#)

O,O-Dimethyl O-(p-nitrophenyl) phosphorothioate
(O,O-Dimethyl O-p-nitrophenyl thiophosphate) (MPT)
(Methyl parathion) (Paridol)

		Annual Capacity (Millions of Pounds)	Types and Remarks
American Cyanamid Company			
Agricultural Division			
Linden, New Jersey		28	Not operating
Hercules Incorporated			
Synthetics Department			
Plaquemine, Louisiana		15	(Methyl parathion); not operating
Kerr-McGee Corporation			
Kerr-McGee Chemical Corp., subsidiary			
Hamilton, Mississippi	(Metron®)	14	(Methyl parathion)
Monsanto Company			
Monsanto Commercial Products Company			
Agricultural Division			
Anniston, Alabama	(Nitran®)	50	(Ethyl, methyl parathion)
Stauffer Chemical Company			
Agricultural Chemical Division			
Mt. Pleasant, Tennessee		30	(Ethyl, methyl parathion)
	TOTAL	137	

Sources: Chemical Marketing Reporter, May 21, 1973, and the Wall Street Journal, December 19, 1973.

O,O-Dimethyl-s-(4-oxo-1,2,3-benzotriazin-3-[4H]-ylmethyl) phosphorodithioate (Azinphosmethyl)
(Benzotriazinedithiophosphoric acid, dimethoxy ester)
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (Guthion®)

2-(2,6-Dimethylphenylamino)-[4H]-5,6-dihydro-1,3-thiazine hydrochloride
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri

1,1-Dimethyl-3-phenylurea trichloroacetate
(Fenuron TCA)
Allied Chemical Corporation
Union Texas Petroleum Division
Agricultural Department
Baltimore, Maryland (Urab®)

Dimethyl phosphate of 3-hydroxy-N,N-dimethyl-cis-crotonamide (See: 3-[Dimethoxyphosphinyloxy]-N,N-dimethyl-cis-crotonamide)

Dimethyl phosphate of 3-hydroxy-N-methyl-cis-crotonamide (See: 3-Hydroxy-N-methyl-cis-crotonamide-dimethyl phosphate)

Dimethyl phosphate of #-methylbenzyl-3-hydroxy-cis-crotonate (See: O,O-Dimethyl O-[1-methyl-2-(1-phenylcarbethoxy) vinyl] phosphate)

O,S-Dimethyl phosphoramidothioate
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri

Dimethyl phthalate

O,O-Dimethyl S-phthalimidomethyl phosphorodithioate (N-[Mercaptomethyl] phthalimide S-[O,O-dimethyl phosphorodithioate] ester) (Prolate)
Stauffer Chemical Company
Agricultural Chemical Division
Henderson, Nevada (Imidan#)

Dimethyl tetrachloroterephthalate (DCPA)
Diamond Shamrock Corporation
Diamond Shamrock Chemical Company
Agricultural Division
Greens Bayou, Texas (Dacthal#)

3,5-Dimethyl-1,3,5-2H-tetrahydrothiadiazine-2-thione (2-Thio-3,5-dimethyl-1,3,5-tetrahydrothiadiazine) (DMTT) (Dazomet)
W. A. Cleary Corporation
New Brunswick, New Jersey (Preservit#)
Merck & Co., Inc.
Merck Chemical Division
Hawthorne, New Jersey
Stauffer Chemical Company
Specialty Chemical Division
Ardsley, New York (Biocide#N 521)

O,O-Dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate (Chlorphos) (Trichlorfon)
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (Dipterex#)
(Dylox#)
(Neguvon#)

Dimethyl-1-(2,4,5-trichlorophenyl)-2-chlorovinyl phosphate (2-Chloro-1-[2,4,5-trichlorophenyl]

vinyl dimethyl phosphate)
Shell Chemical Company
Agricultural Division
Mobile, Alabama (Gardona®)

O,O-Dimethyl O-(2,4,5-trichlorophenyl) phosphorothioate (Dimethyl 2,4,5-trichlorophenyl phosphorothionate) (Fenchlorfos) (Ronnel)
Dow Chemical U.S.A.
Midland, Michigan (Korlan®)
(Trolene®)

1,1-Dimethyl-3-(α,α,α-trifluoro-m-tolyl) urea (3-[m-Trifluoromethylphenyl]-1,1-dimethylurea) (Fluometuron)
Ciba-Geigy Corporation
Agricultural Division
McIntosh, Alabama (Cotoran®)
Nor-Am Agricultural Products, Inc.
Chicago, Illinois

m-(3,3-Dimethylureido) phenyl-tert-butylcarbamate
FMC Corporation
Chemical Group
Agricultural Chemical Division
Middleport, New York

4,6-Dinitro-o-sec-butylphenol (See: 2-sec-Butyl-4,6-dinitrophenol)

Dinitrobutylphenol, ammonium salt
Dow Chemical U.S.A.
Midland, Michigan

2,4-Dinitro-6-sec-butylphenyl isopropylcarbonate (See: Dinobuton)

Dinitrocaprylphenyl crotonate (2-[1-Methylheptyl]-4,6-dinitrophenyl crotonate)
Rohm and Haas Company
Bristol, Pennsylvania (Karathane®)
Philadelphia, Pennsylvania

4,6-Dinitro-o-cresol (DNC) (DNOC)
Blue Spruce Company
Edison, New Jersey

4,6-Dinitro-o-cresol, sodium salt (2-Methyl-4,6-dinitrophenol, sodium salt)
Blue Spruce Company
Edison, New Jersey

2,6-Dinitro-N,N-dipropyl-p-toluidine
Eli Lilly and Company
Tippecanoe Laboratories
Lafayette, Indiana

4,6-Dinitrophenol-o-sec-butylphenol (See: 2-sec-Butyl-4,6-dinitrophenol)

2,4'-Dinitro-4-trifluoromethyldiphenyl ether
Ciba-Geigy Corporation
Agricultural Division
McIntosh, Alabama (Preforan®)

Dinobuton (2-sec-Butyl-4,6-dinitrophenyl isopropyl carbonate) (2,4-Dinitro-6-sec-butylphenyl isopropyl carbonate)
Union Carbide Corporation
Chemicals and Plastics Division
Institute and South Charlest (Dessin®)

Dinoseb (See: 2-sec-Butyl-4,6-dinitrophenol)

p-Dioxane-2,3-diyl ethyl phosphorodithioate (2,3-p-Dioxane-S,S-bis [O,O-diethylphosphorodithioate]) (2,3-p-Dioxanedithiol S,S-bis [O,O-diethyl phosphorodithioate]) (Dioxanthion)
Hercules Incorporated
Synthetics Department
Hattiesburg, Mississippi (Delnav®)

Dioxanthion (See: p-Dioxane-2,3-diyl ethyl phosphorodithioate)

Dipterex® (See: O,O-Dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate)

Diphacinone (See: 2-Diphenylacetyl-1,3-indandione)

Diphenatrile (See: Diphenylacetonitrile)

Diphenyl (See: Biphenyl)

Diphenylacetonitrile (Diphenatrile) (Diphenyl-α-cyanomethane) (Diphenylmethylcyanide) (α-Phenylbenzylcyanide)
Ashland Oil, Inc.
Ashland Chemical Company, division
Chemical Products Division
Great Meadows, New Jersey
Eli Lilly and Company
Tippecanoe Laboratories
Lafayette, Indiana

2-Diphenylacetyl-1,3-indandione-1-hydrazone
(Diphacinone)
Nease Chemical Company, Inc.
State College, Pennsylvania

Diphenylamine

Diphenylmercuriammonium propionate
Merck & Co., Inc.
Merck Chemical Division
Hawthorne, New Jersey

Di(phenylmercury)dodecenyl succinate (Super Adit)
Tenneco Inc.
Tenneco Chemicals, Inc.
Intermediates Division
Elizabeth, New Jersey
Long Beach, California

Di-n-propyl isocinchomeronate
McLaughlin Gormley King Company
Minneapolis, Minnesota

Di-n-propyl 6,7-methylenedioxy-3-methyl-1,2,3,4-tetrahydronaphthalene-1,2-dicarboxylate (Di-n-propylmaleate isosafrole condensate) (n-Propyl isome)
CPC International, Inc.
S. B. Penick & Company, division
Montville, New Jersey

Disodium methane arsonate (See: Methanearsonic acid, disodium salt)

Disodium methyl arsonate (See: Methanearsonic acid, disodium salt)

Disul-sodium (See: 2-[2,4-Dichlorophenoxy] ethanol sulfate, sodium salt)

Disulfoton (See: O,O-Diethyl S-[2-(ethylthio) ethyl] phosphorodithioate)

Di-syston® (See: O,O-Diethyl S-[2-(ethylthio) ethyl] phosphorodithioate)

Dithane® (See: Ethylene bis [dithiocarbamic acid], salts)

Dithiobis thiocarbonyl iminoethylene bis dithiocarbamic acid, zinc salt (Polyram)
FMC Corporation
Chemical Group

Agricultural Chemical Division
Middleport, New York (Polyram®)

Dithiodemeton (See: O,O-Diethyl S-[2-(ethylthio) ethyl] phosphorodithioate)

Dithiosystox (See: O,O-Diethyl S-[2-(ethylthio) ethyl] phosphorodithioate)

Diuron (See: 3-[3,4-Dichlorophenyl]-1,1-dimethylurea)

Dodecachloro-octahydro-1,3,4-metheno-2H-cyclobuta [cd] pentalene (Mirex) (Perchloropentacyclodecane)
Occidental Petroleum Corporation
Hooker Chemical Corporation, subsidiary
Electrochemical and Specialties Divisions
Niagara Falls, New York (Dechlorane®)

Dodecylguanidine acetate (Dodine)
American Cyanamid Company
Agricultural Division
Linden, New Jersey (Cyprex®)

Dodecylguanidine hydrochloride
American Cyanamid Company
Industrial Chemicals and Plastics Division
Linden, New Jersey

Dodine (See: Dodecylguanidine acetate)

Drinox H-34 (See: Heptachlor)

Duphar® (See: p-Chlorophenyl 2,4,5-trichlorophenyl sulfone)

Dybar® (See: 1,1-Dimethyl-3-phenylurea)

Dyfonate® (See: O-Ethyl-S-phenylethylphosphonodithioate)

Dylox® (See: O,O-Dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate)

Dyrene® (See: 2,4-Dichloro-6-[o-chloroaniline]-s-triazine)

EDB (See: 1,2-Dibromoethane)

EDC (See: Ethylene dichloride)

EGT (See: Ethyleneglycol bis [trichloroacetate])

EPN# (See: O-Ethyl O-[p-nitrophenyl] phenyl phosphonothioate)

EPTC (See: S-Ethyl N,N-di-n-propylthiocarbamate)

EXD (See: Diethyl dithiobis [thionoformate])

Emmi# (See: N-Ethylmercuri-1,2,3,6-tetrahydro-3,6-endomethane-3,4,5,6,7,7-hexachlorophthalimide)

Endosulfan (See: 6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxanthiopin-3-oxide)

Endothal# (See: 7-Oxabicyclo [2.2.1] heptane-2,3-dicarboxylic acid, disodium salt)

Endrin (1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4#,5,6,7,8,8#-octahydro-1,4-endo,endo-5,8-dimethanonaphthalene)
  Northwest Industries, Inc.
    Velsicol Chemical Corporation, subsidiary
      Memphis, Tennessee

Entex# (See: O,O-Dimethyl-O-[4-(methylthio)-m-tolyl] phosphorothioate)

Eptam# (See: S-Ethyl N,N-di-n-propylthiocarbamate)

Erbon (See: 2-[2,4,5-Trichlorophenoxy] ethyl 2,2-dichloropropionate)

Ethion (O,O,O',O'-Tetraethyl S,S'-methylene bis-phosphorodithioate)
  FMC Corporation
    Chemical Group
      Industrial Chemical Division
        Baltimore, Maryland

Ethohexadiol (See: 2-Ethyl-1,3-hexanediol)

Ethoxyquin (6-Ethoxy-1,2-dihydro-2,2,4-trimethyl-quinoline)
  Monsanto Company
    Monsanto Commercial Products Company
      Agricultural Division
        Nitro, West Virginia (Santoquin# Liquids)

Ethrel# (See: 2-Chloroethyl phosphonic acid)

2-(Ethylamino)-4-(isopropylamino)-6-methoxy-s-triazine (Atratrone) (Gesatarin)
  Ciba-Geigy Corporation
    Agricultural Division
      McIntosh, Alabama

2-Ethylamino-4-isopropylamino-6-methyl-s-triazine
  Ciba-Geigy Corporation
    Agricultural Division
      McIntosh, Alabama (EvikTM®)

S-Ethyl cyclohexylethylthiocarbamate (See: S-Ethyl N-ethyl-N-cyclohexylthiocarbamate)

Ethyl 4,4'-dichlorobenzilate (Chlorobenzilate)
  Ciba-Geigy Corporation
    Agricultural Division
      McIntosh, Alabama

S-Ethyl diisobutylthiocarbamate (Butylate)
  Stauffer Chemical Company
    Agricultural Chemical Division
      Cold Creek, Alabama (Sutan®)

O-Ethyl S,S-dipropyl phosphorodithioate (Prophos)
  Mobil Oil Corporation
    Mobil Chemical Company, division
      Industrial Chemicals Division
        Mt. Pleasant, Tennessee (Mocap®)

S-Ethyl N,N-di-n-propylthiocarbamate (EPTC)
  Stauffer Chemical Company
    Agricultural Chemical Division
      Cold Creek, Alabama (Eptam®)

Ethylene

Ethylene aldehyde (See: Acrolein)

Ethylene bis (dithiocarbamic acid), diammonium salt (Amobam)
  Blue Spruce Company
    Edison, New Jersey
  Fike Chemicals, Inc.
    Nitro, West Virginia

Ethylene bis (dithiocarbamic acid), disodium salt (Disodium ethylene bis dithiocarbamate) (Nabam)
  Blue Spruce Company
    Edison, New Jersey
  Fike Chemicals, Inc.

Nitro, West Virginia
FMC Corporation
Chemical Group
Agricultural Chemical Division
Middleport, New York
Rohm and Haas Company
Philadelphia, Pennsylvania (Dithane®)

Ethylene bis (dithiocarbamic acid), manganese salt
(Maneb) (MEB)
Blue Spruce Company
Edison, New Jersey
E. I. du Pont de Nemours & Company, Inc.
Biochemicals Department
La Porte, Texas (Manzate®)
Rohm and Haas Company
Philadelphia, Pennsylvania (Dithane®)

Ethylene bis (dithiocarbamic acid), zinc salt (Zineb)
(Parazate)
Blue Spruce Company
Edison, New Jersey
FMC Corporation
Chemical Group
Agricultural Chemical Division
Middleport, New York
Pennwalt Corporation
Chemical Division
Wyandotte, Michigan
Rohm and Haas Company
Philadelphia, Pennsylvania (Dithane®)

Ethylene dibromide

Ethylene dichloride

Ethylene glycol bis (trichloroacetate) (EGT)
Occidental Petroleum Corporation
Hooker Chemical Corporation, subsidiary
Electrochemical and Specialties Divisions
Niagara Falls, New York (Glytac®)

Ethylene oxide

S-Ethyl N-ethyl-N-cyclohexylthiocarbamate
(S-Ethyl cyclohexylethylthiocarbamate) (Cycloate)
Stauffer Chemical Company
Agricultural Chemical Division
Cold Creek, Alabama (Ro-neet®)

Ethyl formate

S-Ethyl hexahydro-1H-azepine carbothioate (Ethyl 1-hexamethylene imine carbothiolalate) (Molinate)
Stauffer Chemical Company
Agricultural Chemical Division
Cold Creek, Alabama (Ordram®)

2-Ethyl-1,3-hexanediol (Ethohexadiol) (2-Ethyl-3-propyl-1,3-propanediol)
Union Carbide Corporation
Chemicals and Plastics Division
Institute and South Charleston, West Virginia

N-(2-Ethylhexyl) bicyclo-(2.2.1)-5-heptene-2,3-dicarboximide (N-Octylbicycloheptenedicarboximide) (Octacide 264)
McLaughlin Gormley King Company
Minneapolis, Minnesota (MGK® 264)

Ethylmercury chloride (Chloroethylmercury) (Ethyl mercuric chloride)
Eli Lilly and Company
Tippecanoe Laboratories
Lafayette, Indiana

Ethyl methylene phosphorodithioate (See: Ethion)

Ethyl 4-(methylthio)-m-tolyl isopropylphosphoramidate
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri

Ethyl parathion (See: O,O-Diethyl O-[p-nitrophenyl] phosphorothioate)

O-Ethyl-S-phenyl-ethylphosphonodithioate
Stauffer Chemical Company
Agricultural Chemical Division
Cold Creek, Alabama

2-Ethyl-3-propyl-1,3-propanediol (See: 2-Ethyl-1,3-hexanediol)

Ethyl pyrophosphate (Tetraethylpyrophosphate) (TEPP)
Alco Standard Corporation
Miller Chemical and Fertilizer Corporation, subsidiary
Hanover, Pennsylvania

S-2-(Ethylsulfinyl) ethyl O,O-dimethyl phosphorothioate (See: O,O-Dimethyl S-2-[ethylsulfinyl] ethyl phosphorodithioate)

O-[2-(Ethylthio) ethyl] O,O-dimethyl phosphorothioate (See: O,O-Dimethyl S-2-[ethylsulfinyl] ethyl phosphorodithioate)

Ethyl xanthogen disulfide
  Pike Chemicals, Inc.
    Nitro, West Virginia

Famphur (See: O,O-Dimethyl O-p-[dimethylsulfamoyl] phenyl phosphorothioate)

Fenac® (See: [2,3,6-Trichlorophenyl] acetic acid)

Fenchlorfos (See: O,O-Dimethyl O-[2,4,5-trichlorophenyl] phosphorothioate)

Fenoprop (See: 2-[2,4,5-Trichlorophenoxy] propionic acid)

Fensulfothion (See: O,O-Diethyl O-p-[methylsulfinyl] phenyl phosphorothioate)

Fenthion (See: O,O-Dimethyl O-[4-(methylthio)-m-tolyl] phosphorothioate)

Fenuron TCA (See: 1,1-Dimethyl-3-phenylurea trichloroacetate)

Ferbam (See: Dimethyldithiocarbamic acid, ferric salt)

Ferberk® (See: Dimethyldithiocarbamic acid, ferric salt)

Fluometuron (See: 1,1-Dimethylurea-3-[α,α,α-trifluoro-m-tolyl] urea)

Folex® (See: Tributyl phosphorotrithioite)

Folpet (See: N-[Trichloromethylthio] phthalimide)

Formaldehyde

Formalin (See: Formaldehyde)

Formetanate hydrochloride (See: m-[([Dimethylamino]-methylene)amino] phenyl methyl carbamate hydrochloride)

Fruitone (See: p-Chlorophenoxyacetic acid)

Fukiasin (See: Dimethyldithiocarbamic acid, zinc salt)

Fundal (See: N,N-Dimethyl-N'-[2-methyl-4-chlorophenyl] formamidine)

Furadan® (See: 2,3-Dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate)

3-(1-Furyl-3-acetylethyl)-4-hydroxycoumarin
(3-[α-Acetonylfurfuryl]-4-hydroxycoumarin)
(Coumafuryl)
Rorer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania
Fremont, California
St. Joseph, Missouri

Gardona® (See: Dimethyl-1-[2,4,5-trichlorophenyl]-2-chlorovinyl phosphate)

Genite® 923 (See: 2,4-Dichlorophenyl benzenesulfonate)

Gesagard (See: 2,4-Bis [isopropylamino]-6-methylthio-s-triazine)

Gibberellic acid (Gibberellin)
Abbott Laboratories
Agricultural/Veterinary Products Division
North Chicago, Illinois (Pro-Gibb®)
Merck & Co., Inc.
Merck Chemical Division
Danville, Pennsylvania

Glyodin (2-Heptadecyl-2-imidazoline)
Union Carbide Corporation
Chemicals and Plastics Division
Institute and South Charleston, West Virginia

Glytac® (See: Ethylene glycol bis [trichloroacetate])

Goodrite Z.I.P. (See: Dimethyldithiocarbamic acid, zinc salt)

Gophacide® (See: O,O-Bis [p-chlorophenyl] acetimidoylphosphoramidothioate)

Guthion® (See: O,O-Dimethyl s-[4-oxo-1,2,3-benzotriazin-3-(4H)-ylmethyl] phosphorodithioate)

HCA (See: Hexachloroacetone)

HCB (See: Hexachlorobenzene)

Heptachlor (1,4,5,6,7,8,8a-Heptachlorodicyclopentadiene) (1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene) (Heptachloro-tetrahydro-endo-methanoindene) (Drinox H-34)
  Northwest Industries, Inc.
    Velsicol Chemical Corporation, subsidiary
      Memphis, Tennessee

2-Heptadecyl-2-imidazoline (See: Glyodin)

Herban® (See: 3-[Hexahydro-4,7-methanoindan-5-yl]-1,1-dimethylurea)

Herbisan® (See: Diethyl dithiobis [thionoformate])

Hexachloroacetone (HCA) (Hexachloro-2-propanone)
  Allied Chemical Corporation
    Specialty Chemicals Division
      Baton Rouge, Louisiana

Hexachlorobenzene

α,β-1,2,3,4,7,7-Hexachlorobicyclo [2.2.1]-hepten-5,6-bisoxymethylene sulfite (See: 6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3-oxide)

Hexachlorocyclohexane (Benzene hexachloride) (BHC)
  Occidental Petroleum Corporation
    Hooker Chemical Corporation, subsidiary
      Electrochemical and Specialties Divisions
        Niagara Falls, New York

1,2,3,4,5,6-Hexachlorocyclohexane, 100% γ-isomer (Lindane)
  Occidental Petroleum Corporation
    Hooker Chemical Corporation, subsidiary
      Electrochemical and Specialties Divisions
        Niagara Falls, New York (HGI®)
  Prentiss Drug & Chemical Co., Inc.
        Newark, New Jersey

Hexachloro dimethyl sulfone
  Stauffer Chemical Company
    Specialty Chemical Division
      Ardsley, New York

1,2,3,4,10,10-Hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1,4-endo-endo-5,8-

dimethanonaphthalene (See: Endrin)

Hexachloro-epoxy-octahydro-endo, exomethano-naphthalene (See: Dieldrin)

Hexachloro-hexahydro-endo-exo-dimethano-naphthalene (See: Aldrin)

6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxanthiepin-3-oxide (**-1,2,3,4,7,7-Hexachlorobicyclo [2.2.1]-hepten-5,6-bisoxymethylene sulfite) (1,4,5,6,7,7-Hexachloro-5-norbornene-2,3-dimethanol, cyclic sulfite) (Endosulfan)
  FMC Corporation
    Chemical Group
      Agricultural Chemical Division
        Middleport, New York (Thiodan®)

Hexachloro-2-propanone (See: Hexachloroacetone)

Hormodin® (See: Indole-3-butyric acid)

Hydrogen cyanide

Hydrothal (See: 7-Oxabicyclo [2.2.1] heptane-2,3-dicarboxylic acid)

2-Hydroxybiphenyl (See: o-Phenylphenol)

3-Hydroxycrotonic acid, methyl ester, dimethyl phosphate (See: O,O-Dimethyl O-[2-carbomethoxy-1-methylvinyl] phosphate)

Hydroxydimethylarsine oxide (See: Cacodylic acid)

3-Hydroxy-N,N-dimethyl-cis-crotonamide-dimethyl phosphate (See: 3-[Dimethoxyphosphinyloxy]-N,N-dimethyl-cis-crotonamide)

2-Hydroxyethyl-n-octylsulfide (Repellent 874)
  McLaughlin Gormley King Company
    Minneapolis, Minnesota

(Hydroxymercuri) benzene (See: Phenylmercury hydroxide)

3-Hydroxy-N-methyl-cis-crotonamide-dimethyl-phosphate
  Shell Chemical Company
    Agricultural Division
      Denver, Colorado (Azodrin®)

N-Hydroxynaphthalimide diethyl phosphate
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri

Hydroxyphenylmercury (See: Phenylmercury hydroxide)

2-Hydroxypropyl methanethiolsulfonate
Buckman Laboratories, Inc.
Cadet, Missouri
Memphis, Tennessee

8-Hydroxyquinoline, copper salt (See: 8-Quinolinol, copper salt)

Hyvar® (See: 5-Bromo-3-sec-butyl-6-methyluracil)

IPC (See: Isopropyl N-phenylcarbamate)

Igran 80W® (See: 2-tert-Butylamino-4-ethylamino-6-methylthio-s-triazine)

Imidan® (See: O,O-Dimethyl S-phthalimidomethyl phosphorodithioate)

Indalone® (See: Butyl mesityl oxide oxalate)

Indole-3-butyric acid (4-[3-Indolyl] butyric acid)
Syntex Corporation
Arapahoe Chemicals Division
Boulder, Colorado

Ioxynil (3,5-Diiodo-4-hydroxybenzonitrile)
Rorer-Amchem
Amchem Products, Inc., division
Fremont, California

Isobornyl thiocyanoacetate (Terpinyl thiocyanoacetate) (Thanite)
Blue Spruce Company
Edison, New Jersey
Hercules Incorporated
Synthetics Department
Brunswick, Georgia
McLaughlin Gormley King Company
Minneapolis, Minnesota

Isocil (See: 5-Bromo-3-sec-butyl-6-methyluracil)

o-Isopropoxyphenyl methyl carbamate (2-Isopropoxyphenyl N-methylcarbamate) (Propoxur)
Baychem Corporation

Chemagro Corporation, division
Kansas City, Missouri (Baygon®)

Isopropyl carbanilate (See: Isopropyl N-phenylcarbamate)

Isopropyl 3-chlorocarbanilate (3-Chlorocarbanilic acid, isopropyl ester) (Isopropyl N-[3-chlorophenyl] carbamate) (Chloro-IPC) (Chloropropham) (CIPC)
PPG Industries, Inc.
Chemical Division
Industrial Chemical Division
Barberton, Ohio

Isopropyl N-(3-chlorophenyl) carbamate (See: Isopropyl 3-chlorocarbanilate)

Isopropyl 4,4'-dichlorobenzilate
Ciba-Geigy Corporation
Agricultural Division
McIntosh, Alabama (Acaralate®)

Isopropyl N-phenylcarbamate (Isopropyl carbanilate) (IPC) (Propham)
PPG Industries, Inc.
Chemical Division
Industrial Chemical Division
Barberton, Ohio

KOCN (See: Potassium cyanate)

Kalzate® T.P. 6 (See: [2,4,5-Trichlorophenoxy]propionic acid, potassium salt)

Karathane® (See: Dinitrocaprylphenyl crotonate)

Karbutilate (See: m-[3,3-Dimethylureido]phenyl-tert-butylcarbamate)

Karmex® (See: 3-[3,4-Dichlorophenyl]-1,1-dimethylurea)

Kelthane (See: 4,4'-Dichloro-α-[trichloromethyl] benzhydrol)

Kepone® (See: Decachloro-octahydro-1,3,4-metheno-2H-cyclobuta [CD] pentalen-2-one)

Kloben® (See: 3-[3,4-Dichlorophenyl]-1-methyl-1-n-butylurea)

Korlan® (See: O,O-Dimethyl O-[2,4,5-trichlorophenyl] phosphorothioate)

(Lactoyloxy) phenylmercury (See: Phenylmercury lactate)

Landrin# (See: 2,3,5-Trimethylphenyl methylcarbamate)

Lannate# (See: S-Methyl N-[(methylcarbamoyl) oxy] thioacetimidate)

Lanstan# (See: 1-Chloro-2-nitropropane)

Lasso# (See: 2-Chloro-2,6' diethyl-N-(methoxymethyl) acetanilide)

Lead arsenate (Plumbous arsenate)
  Chempar Chemical Co., Inc.
      Portland, Oregon
  Dimensional Pigments, Inc.
      Bayonne, New Jersey
  FMC Corporation
    Chemical Group
      Agricultural Chemical Division
        Middleport, New York
  Los Angeles Chemical Company
      South Gate, California
  Somerset Tire Co.
      Bound Brook, New Jersey
  Standard Oil Company of California
    Chevron Chemical Company, subsidiary
      Ortho Division
        Richmond, California

Lebaycid (See: O,O-Dimethyl O-[4-(methylthio)-m-tolyl] phosphorothioate)

Leptophos (See: O-[4-Bromo-2,5-dichlorophenyl]-O-methyl phenylphosphorothioate)

Lethane 384 (See: 2-[2-Butoxyethoxy] ethyl thiocyanate)

Lindane (See: 1,2,3,4,5,6-Hexachlorocyclohexane, 100% #-isomer)

Linuron (See: 3-[3,4-Dichlorophenyl]-1-methoxy, 1-methylurea)

Liquiphene# (See: Phenylmercury acetate)

Lithate# 2,4-D (See: [2,4-Dichlorophenoxy] acetic acid, lithium salt)

Lithate# 2,4,5-T (See: [2,4,5-Trichlorophenoxy] acetic acid, lithium salt)

Lithate# 2,4,5-TP (See: [2,4,5-Trichlorophenoxy]-propionic acid, lithium salt)

Lorox# (See: 3-[3,4-Dichlorophenyl]-1-methoxy, 1-methylurea)

MCP (See: [4-Chloro-o-tolyloxy] acetic acid)

MCPA (See: [4-Chloro-o-tolyloxy] acetic acid)

MCPB (See: 4-[2-Methyl-4-chlorophenoxy] butyric acid)

MGK 264# (See: N-[2-Ethylhexyl] bicyclo-[2.2.1]-5-heptene-2,3-dicarboximide)

MH (See: Maleic hydrazide)

MSMA (See: Methanearsonic acid, monosodium salt)

Malachite green (See: Copper carbonate)

Malathion (S-[1,2-Bis (ethoxycarbonyl) ethyl] O,O-dimethyl phosphorodithioate) (S-[1,2-Dicarbethoxyethyl] O,O-dimethyl dithiophosphate) (Mercaptosuccinic acid, diethyl ester, O,O-dimethyl dithiophosphate)
American Cyanamid Company
Agricultural Division
Linden, New Jersey
Blue Spruce Company
Edison, New Jersey
Prentiss Drug & Chemical Co., Inc.
Newark, New Jersey

Maleic hydrazide (1,2-Dihydro-3,6-pyridazinedione)
The Ansul Company
Chemical Division
Marinette, Wisconsin (Sucker-Stuff#)
Chemical Formulators, Inc.
Chemical Division
Nitro, West Virginia
Fairmount Chemical Co., Inc.
Newark, New Jersey

Maneb (See: Ethylene bis [dithiocarbamic acid], manganese salt)

Marlate* (See: 1,1,1-Trichloro-2,2-bis [p-methoxyphenyl] ethane)

Matacil* (See: 4-[Dimethylamino]-m-tolyl methylcarbamate)

Memmi* (See: N-[Methylmercuri]-1,4,5,6,7,7-hexachlorobicyclo [2.2.1] hept-5-ene-2,3-dicarboximide)

2-Mercaptobenzothiazole, zinc salt (Zinc MBT)
American Cyanamid Company
Organic Chemicals Division
Bound Brook, New Jersey
E. I. du Pont de Nemours & Company, Inc.
Elastomer Chemicals Department
Deepwater Point, New Jersey
The B. F. Goodrich Company
B. F. Goodrich Chemical Company, division
Henry, Illinois
The Goodyear Tire & Rubber Company
Chemical Division
Niagara Falls, New York

N-(2-Mercaptoethyl) benzenesulfonamide-S-(O,O-diisopropyl phosphorodithioate) ester (See: N-[β-O,O-Diisopropyldithiophosphorylethyl] benzene sulfonamide)

N-(Mercaptomethyl) phthalimide S-(O,O-dimethyl phosphorodithioate) ester (See: O,O-Dimethyl S-phthalimidomethyl phosphorodithioate)

Mercaptophos (See: O,O-Diethyl O [and S] - (2-(ethylthio) ethyl] phosphorothioates)

Mercaptosuccinic acid, diethyl ester, O,O-dimethyl dithiophosphate (See: Malathion)

Mercurial turf fungicides
Mallinckrodt Chemical Works
Industrial Chemicals Division
St. Louis, Missouri

Mercuric chloride (See: Mercury bichloride)

Metadelphene* (See: N,N-Diethyl-m-toluamide)

Meta-Systox* (See: O,O-Dimethyl S-2-[ethylsulfinyl] ethyl phosphorodithioate)

Metam (See: N-Methyldithiocarbamic acid, sodium salt)

Metham (See: N-Methyldithiocarbamic acid, sodium salt)

Methanearsonic acid, calcium acid salt (Calcium acid methyl arsonate)

Methanearsonic acid, disodium salt (DSMA)
(Methar) (Disodium methane arsonate) (Disodium methyl arsonate)
The Ansul Company
Chemical Division
Marinette, Wisconsin (Ansar® 184,8100)
W. A. Cleary Corporation
New Brunswick, New Jersey
Diamond Shamrock Corporation
Diamond Shamrock Chemical Company
Agricultural Division
Greens Bayou, Texas

Methanearsonic acid, dodecyl- and octyl-ammonium salts
W. A. Cleary Corporation
New Brunswick, New Jersey

Methanearsonic acid, monosodium salt (MSMA)
(Monosodium methyl arsonate)
The Ansul Company
Chemical Division
Marinette, Wisconsin (Ansar® 170 H.C., 529 H.C.)
Diamond Shamrock Corporation
Diamond Shamrock Chemical Company
Agricultural Division
Greens Bayou, Texas

Methazate (See: Dimethyldithiocarbamic acid, zinc salt)

Methomyl (See: S-Methyl N-[(methylcarbamoyl) oxy] thioacetimidate)

2-Methoxy-4,6-bis (isopropylamino)-s-triazine
(Prometone)
Ciba-Geigy Corporation
Agricultural Division
McIntosh, Alabama (Pramitol®)

Methoxychlor (See: 1,1,1-Trichloro-2,2-bis [p-methoxyphenyl] ethane)

Methoxy DDT (See: 1,1,1-Trichloro-2,2-bis [p-methoxyphenyl] ethane)

Methyl bromide (See: Bromomethane)

Methyl-1-(butylcarbamoyl)-2-benzimidazole carbamate
E. I. du Pont de Nemours & Company, Inc.
Biochemicals Department
Belle, West Virginia (Benlate#)

2-Methyl-4-chlorophenoxyacetic acid (See: [4-Chloro-o-tolyloxy] acetic acid)

4-(2-Methyl-4-chlorophenoxy) butyric acid sodium salt (Cantrol)
Rorer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania
Fremont, California
St. Joseph, Missouri

(2-[2-Methyl-4-chlorophenoxy]propionic acid)
PBI-Gordon Corporation
Kansas City, Kansas

Methyl-demeton (See: O,O-Dimethyl S-2-[ethylsulfinyl] ethyl phosphorodithioate)

Methyl 3-(dimethoxyphosphinyloxy) crotonate (See: O,O-Dimethyl O-[2-carbomethoxy-1-methylvinyl] phosphate)

2-Methyl-4,6-dinitrophenol, sodium salt (See: 4,6-Dinitro-o-cresol, sodium salt)

N-Methyldithiocarbamic acid, potassium salt (Busan#)
Buckman Laboratories, Inc.
Cadet, Missouri
Memphis, Tennessee

N-Methyldithiocarbamic acid, sodium salt (Metam) (Metham) (SMDC) (VPM)
Chemical Formulators, Inc.
Chemical Division
Nitro, West Virginia
E. I. du Pont de Nemours & Company, Inc.
Biochemicals Department
La Porte, Texas
Stauffer Chemical Company
Agricultural Chemical Division
Ardsley, New York (Vapam#)
Richmond, California (Vapam#)

Methylenebis thiocyanate

American Cyanamid Company
Industrial Chemicals and Plastics Division
Linden, New Jersey
Buckman Laboratories, Inc.
Cadet, Missouri
Memphis, Tennessee
Merck & Co., Inc.
Merck Chemical Division
Hawthorne, New Jersey

1,2-Methylenedioxy-4-[2-(octylsulfinyl) propyl]
benzene (See: Sulfoxide)

(Methylenedioxy-6-propylbenzyl) (butyl)-
diethylene glycol ether (See: Piperonyl butoxide)

2-(1-Methylheptyl)-4,6-dinitrophenyl crotonate
(See: Dinitrocaprylphenyl crotonate)

Methyl-m-hydroxycarbanilate-m-methylcarbanilate
(Phenmedipham)
Nor-Am Agricultural Products, Inc.
Chicago, Illinois (Betanal®)

Methyl isothiocyanate (20%) and 1,2-Dichloropropane/
1,3-Dichloropropene (80%) mixture
Nor-Am Agricultural Products, Inc.
Chicago, Illinois (Vorlex®)

2-Methylmercapto-4,6-bis (isopropylamino)-s-triazine
(See: 2,4-Bis [isopropylamino]-6-methylthio-s-triazine)

Methylmercury nitrile

Methylmercury quinolinolate (See: 8-[Methyl-
mercurioxy] quinoline)

S-Methyl-N-[(methylcarbamoyl) oxy] thio-
acetimidate (Methomyl)
E. I. du Pont de Nemours & Company, Inc.
Biochemicals Department
La Porte, Texas (Lannate®)
Shell Chemical Company
Agricultural Division
Denver, Colorado

1-Methyl-2-(3,4-methylenedioxyphenyl) ethyl octyl
sulfoxide (See: Sulfoxide)

2-Methyl-2-(methylthio) propionaldehyde O-(methyl-
carbamoyl) oxime
Union Carbide Corporation

Chemicals and Plastics Division
Institute and South Charlest (Temik®)

Methyl namate (See: Dimethyldithiocarbamic acid, sodium salt under Rubber Processing Chemicals)

Methyl parathion (See: O,O-Dimethyl O-[p-nitrophenyl] phosphorothioate)

Methylphosphoramidic acid, 4-tert-butyl-2-chlorophenyl methyl ester (See: 4-tert-Butyl-2-chlorophenyl methyl methylphosphoramidate)

3-(2-Methylpiperidino) propyl-3,4-dichlorobenzoate (Piperalin)
Eli Lilly and Company
Tippecanoe Laboratories
Lafayette, Indiana (Pipron®)

6-Methyl-2,3-quinoxalinedithiol cyclic-S,S-dithiocarbonate (Oxythioquinox) (Quinomethionate)
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (Morestan®)

4-(Methylsulfonyl)-2,6-dinitro-N,N-dipropylaniline (Nitralin)
Shell Chemical Company
Agricultural Division
Denver, Colorado (Planavin®)

4-(Methylthio)-3,5-xylyl methylcarbamate
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri

Methyl trithion (See: O,O-Dimethyl-S-chlorophenyl thiomethyl phosphorodithioate)

Metron (See: O,O-Dimethyl O-[p-nitrophenyl] phosphorothioate)

Mevinphos (See: O,O-Dimethyl O-[2-carbomethoxy-1-methylvinyl] phosphate)

Milbam (See: Dimethyldithiocarbamic acid, zinc salt under Rubber Processing Chemicals)

Milogard® (See: 2-Chloro-4,6-bis [isopropylamino]-s-triazine)

Mirex (See: Dodecachloro-octahydro-1,3,4-metheno-

2H-cyclobuta [cd] pentalene)

Mocap® (See: O-Ethyl S,S-dipropyl phosphorodithioate)

Molinate (See: S-Ethyl hexahydro-1H-azepine-1-carbothioate)

Monosodium methyl arsonate (See: Methanearsonic acid, monosodium salt)

Monuron (See: 3-[p-Chlorophenyl]-1,1-dimethylurea)

Morestan® (See: 6-Methyl-2,3-quinoxalinedithiol cyclic-S,S-dithiocarbonate)

Morocide® (See: 2-sec-Butyl-4,6-dinitrophenyl-3,3-dimethylacrylate)

NIA 10637 (See: Ethyl hydrogen 1-propyl phosphonate)

NPA (See: N-1-Naphthylphthalamic acid)

Nabam (See: Ethylene bis [dithiocarbamic acid], disodium salt)

Naled (See: O,O-Dimethyl O-[1,2-dibromo-2,2-dichloroethyl] phosphate)

Naphthalene

1-Naphthalene acetamide (α-Naphthylacetamide)
- Millmaster Onyx Corporation
  - Millmaster Chemical Company, division
    - Berkeley Chemical Department
      - Berkeley Heights, New Jersey
- Rorer-Amchem
  - Amchem Products, Inc., division
    - Ambler, Pennsylvania

1-Naphthaleneacetic acid (1-Naphthylacetic acid) (NAA)
- Millmaster Onyx Corporation
  - Millmaster Chemical Company, division
    - Berkeley Chemical Department
      - Berkeley Heights, New Jersey
- Rorer-Amchem
  - Amchem Products, Inc., division
    - Ambler, Pennsylvania

1-Naphthaleneacetic acid, ethyl ester
- Rorer-Amchem

Amchem Products, Inc., division
Ambler, Pennsylvania

1-Naphthaleneacetic acid, sodium salt
Millmaster Onyx Corporation
Millmaster Chemical Company, division
Berkeley Chemical Department
Berkeley Heights, New Jersey
Rorer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania

Naphthenic acid, copper salt (See: Copper naphthenate)

1-Naphthyl N-methylcarbamate (Carbaryl)
Union Carbide Corporation
Chemicals and Plastics Division
Institute and South Charlest (Sevin®)

(2-Naphthyloxy) acetic acid
(β-Naphthoxyacetic acid) (O-[2-Naphthyl] glycolic acid)
Millmaster Onyx Corporation
Millmaster Chemical Company, division
Berkeley Chemical Department
Berkeley Heights, New Jersey

(2-Naphthyloxy) acetic acid, sodium salt
Millmaster Onyx Corporation
Millmaster Chemical Company, division
Berkeley Chemical Department
Berkeley Heights, New Jersey

2-(β-Naphthoxy)-N,N-diethyl propionamide
Stauffer Chemical Company
Agricultural Chemical Division
Richmond, California

N-1-Naphthylphthalamic acid (NPA) (Naptalam)
The Ansul Company
Chemical Division
Marinette, Wisconsin

Naptalam (See: N-1-Naphthylphthalamic acid)

Neguvon® (See: O,O-Dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate)

Nemacide (See: O-2,4-Dichlorophenyl-O,O-diethyl phosphorothioate)

Nemagon# (See: 1,2-Dibromo-3-chloropropane)

Neobor# (See: Sodium borates)

Niagaramite# (See: 2-[p-tert-Butylphenoxy] isopropyl 2'-chloroethyl sulfite)

Nican# (See: O,O-Diethyl O-[p-nitrophenyl] phosphorothioate)

Nitralin (See: 4-[Methylsulfonyl]-2,6-dinitro-N,N-dipropylaniline)

Nitrochloroform (See: Chloropicrin)

Nitrofen (See: 2,4-Dichlorophenyl-p-nitrophenyl ether)

p-Nitrophenyl-#,#,#-trifluoro-2-nitro-p-tolyl ether
  Nor-Am Agricultural Products, Inc.
        Chicago, Illinois

Norbornyl ureas (See: 3-[Hexahydro-4,7-methanoindan-5-yl]-1,1-dimethylurea)

OPP (See: o-Phenylphenol)

1,2,4,5,6,7,8,8-Octachloro-3#,3,7,7#-tetrahydro-4,7-methanoindan (See: Chlordane)

Octacide 264 (See: N-[2-Ethylhexyl]-bicyclo-[2.2.1]-5-heptene-2,3-dicarboximide)

N-Octylbicycloheptenedicarboximide (See: N-[2-Ethylhexyl] bicyclo-[2.2.1]-5-heptene-2,3-dicarboximide)

Octyl dodecylammonium methyl arsonate (See: Methanearsonic acid, dodecyl- and octylammonium salts)

n-Octyl sulfoxide of isosafrole (See: Sulfoxide)

Oleic acid, copper salt (See: Copper oleate)

(Oleoyloxy) phenylmercury (See: Phenylmercury oleate)

Orthophos (See: O,O-Diethyl O-[p-nitrophenyl] phosphorothioate)

Ortho-xenol (See: o-Phenylphenol)

Ovex (See: p-Chlorophenyl-p-chlorobenzenesulfonate)

Ovotran# (See: p-Chlorophenyl-p-chlorobenzenesulfonate)

7-Oxabicyclo [2.2.1] heptane-2,3-dicarboxylic acid, disodium salt (Aquathol) (Hydrothal)
  Pennwalt Corporation
    Chemical Division
      Wyandotte, Michigan (Endothal#)

Oxirane (See: Ethylene oxide)

Oxybis (tributyltin) (See: Bis [tri-n-butyltin] oxide)

Oxythioquinox (See: 6-Methyl-2,3-quinoxalinedithiol cyclic-S,S-dithiocarbonate)

Parathion (See: o,o-Dimethyl O-[p-nitrophenyl] phosphorothioate)

Parazate (See: Ethylene bis [dithiocarbamic acid], zinc salt)

Paridol (See: O,O-Dimethyl O-[p-nitrophenyl] phosphorothioate)

Paris Green (See: Copper acetoarsenite)

PCNB (See: Pentachloronitrobenzene)

PCP (See: 2,3,4,5,6-Pentachlorophenol)

PEBC (See: n-Propylethyl-n-butylthiolcarbamate)

Pebulate (See: n-Propyl ethyl-n-butylthiolcarbamate)

Pentac (See: Decachlorobis [2,4-cyclopentadien-1-yl])

Pentachloronitrobenzene (PCNB)
  Olin Corporation
    Designed Products Division
      Rochester, New York
    Industrial Products and Services Division
McIntosh, Alabama (Terraclor#)

2,3,4,5,6-Pentachlorophenol (PCP)

		Annual Capacity (Millions of Pounds)
Dover Chemical Corporation Dover, Ohio		n.a.
Dow Chemical U.S.A. Midland, Michigan	(Dowicide®7)	15
Monsanto Company Monsanto Industrial Chemicals Company Sauget, Illinois		26
Red Devil Paint Co. Tacoma, Washington	(Chlorophen®)	12
Sonford Chemical Company Houston, Texas		*n.a.
	TOTAL	60

*May not be operating.

Sources: Compiled in association with the Chemical Economics Handbook, and correspondence.

Pentachlorophenol, sodium salt (Sodium pentachlorophenate)
Dover Chemical Corporation
Dover, Ohio
Dow Chemical U.S.A.
Midland, Michigan (Dowicide® G)
Monsanto Company
Monsanto Industrial Chemicals Company
Sauget, Illinois
Red Devil Paint Co.
Tacoma, Washington

Perchloromethyl mercaptan (PMM) (Perchloromethanethiol) (Trichloromethanethiol)
Stauffer Chemical Company
Calhio Chemicals, Inc., subsidiary
Perry, Ohio

Perchloropentacyclodecane (See: Dodecachloro-octahydro-1,3,4-metheno-2H-cyclobuta [cd] pentalene)

Perthane® (See: 1,1-Dichloro-2,2-bis [p-ethylphenyl] ethane)

Pestmaster# (See: Bromomethane)

Phaltan# (See: N-[Trichloromethylthio] phthalimide)

Phelam (See: Phenylmercury dimethyldithiocarbamate)

Phenmedipham (See: Methyl-m-hydroxycarbanilate-m-methylcarbanilate)

Phenothiazine (Dibenzo 1,4-thiazine)
(Thiodiphenylamine)
Prentiss Drug & Chemical Co., Inc.
Newark, New Jersey

Phenoxyacetic acid derivatives (See: [4-Chloro-o-tolyloxy] acetic acid, [2,4-Dichlorophenoxy] acetic acid, and [2,4,5-Trichlorophenoxy] acetic acid)

3-#-Phenyl-#-acetylethyl-4-hydroxycoumarin
(See: Warfarin)

#-Phenylbenzylcyanide (See: Diphenylacetonitrile)

2-(Phenylmercuriamino) ethyl acetate
W. A. Cleary Corporation
New Brunswick, New Jersey

Phenylmercuric benzoate

Phenylmercury acetate (PMA) (PMAS) (Acetoxyphenylmercury) ([Acetoxymercuri] benzene)
W. A. Cleary Corporation
New Brunswick, New Jersey
Cosan Chemical Corporation
Clifton, New Jersey
Merck & Co., Inc.
Merck Chemical Division
Hawthorne, New Jersey (Metasol# 30)
Tenneco Inc.
Tenneco Chemicals, Inc.
Intermediates Division
Elizabeth, New Jersey
Long Beach, California
Troy Chemical Corporation
Newark, New Jersey

Phenylmercuryammonium acetate (N-Phenylmercuric ammonium acetate)
Troy Chemical Corporation
Newark, New Jersey

Phenylmercury borate ([Dihydrogen borato] phenylmercury)
Cosan Chemical Corporation
Clifton, New Jersey
Royce Chemical Company
East Rutherford, New Jersey (Corubex®)
Troy Chemical Corporation
Newark, New Jersey

Phenylmercury chloride (Chlorophenylmercury)

Phenylmercury dimethyldithiocarbamate (Phelam)

Phenylmercury 2-ethylhexanoate
Tenneco Inc.
Tenneco Chemicals, Inc.
Intermediates Division
Elizabeth, New Jersey
Long Beach, California

Phenylmercury hydroxide ([Hydroxymercuri] benzene)
(Phenylmercuric hydroxide)
Merck & Co., Inc.
Merck Chemical Division
Hawthorne, New Jersey

Phenylmercury lactate ([Lactoyloxy] phenylmercury)

Phenylmercury naphthenate
Merck & Co., Inc.
Merck Chemical Division
Hawthorne, New Jersey
Tenneco Inc.
Tenneco Chemicals, Inc.
Intermediates Division
Elizabeth, New Jersey

Phenylmercury nitrate

Phenylmercury oleate ([Oleoyloxy] phenylmercury)
W. A. Cleary Corporation
New Brunswick, New Jersey
Cosan Chemical Corporation
Clifton, New Jersey
Merck & Co., Inc.
Merck Chemical Division
Hawthorne, New Jersey (Metasol® O)
Tenneco Inc.
Tenneco Chemicals, Inc.
Intermediates Division
Elizabeth, New Jersey
Long Beach, California

Troy Chemical Corporation
Newark, New Jersey

Phenylmercury propionate (Phenyl [propionyloxy] mercury)
Merck & Co., Inc.
Merck Chemical Division
Hawthorne, New Jersey (Metasol® 57)

Phenylmercury salicylate (Phenyl [salicyloyloxy] mercury)

2-Phenylphenol (See: o-Phenylphenol)

Phorate (See: O,O-Diethyl S-[ethylthio] methyl phosphorodithioate)

Phosdrin® (See: O,O-Dimethyl O-[2-carbomethoxy-1-methylvinyl] phosphate)

Phosfon® (See: Tributyl [2,4-dichlorobenzyl] phosphonium chloride)

Phosphamidon (O-[2-Chloro-2-(diethylcarbamoyl)-1-methylvinyl] O,O-dimethyl phosphate) (Dimecron)
Standard Oil Company of California
Chevron Chemical Company, subsidiary
Ortho Division
Maryland Heights, Missouri
Orlando, Florida
Richmond, California
South Plainfield, New Jersey

Phosphorothioic acid, O-(2-chloro-1-[2,5-dichlorophenyl] vinyl) O,O-diethyl ester (See: O,O-Diethyl-O-[2-chloro-1-(2,5-dichlorophenyl) vinyl] phosphorothioate)

Phthalimidomethyl-O,O-dimethyl phosphorodithioate (See: O,O-Dimethyl S-phthalimidomethyl phosphorodithioate)

Phytar® 560 (See: Cacodylic acid)

Picloram (See: 4-Amino-3,5,6-trichloropicolinic acid)

Pindone (See: 2-Pivaloyl-1,3-indandione)

Piperalin (See: 3-[2-Methylpiperidino] propyl-3,4-dichlorobenzoate)

Piperazine (Diethylenediamine) (Hexahydro-1,4-diazine) (Hexahydropyrazine) (Lumbrical) (Piperazidine) (Pyrazine hexahydride)
Fleming Laboratories, Inc.
Charlotte, North Carolina
Jefferson Chemical Company, Inc.
Conroe, Texas
Rhodia Inc.
New Brunswick, New Jersey
Union Carbide Corporation
Chemicals and Plastics Division
Taft, Louisiana
Texas City, Texas

Piperazine dihydrochloride
Fleming Laboratories, Inc.
Charlotte, North Carolina
Jefferson Chemical Company, Inc.
Conroe, Texas
Polychemical Laboratories, Incorporated
Bronx, New York
Rohm and Haas Company
Whitmoyer Laboratories, Inc., subsidiary
Myerstown, Pennsylvania

Piperonal bis [2-(2'-n-butoxyethoxy) ethyl] acetal
McLaughlin Gormley King Company
Minneapolis, Minnesota (Tropital#)

Piperonyl butoxide (#-[2-(2-Butoxyethoxy) ethoxy]-4,5-methylenedioxy-2-propyltoluene) (Butylcarbityl [6-propylpiperonyl] ether) ([3,4-Methylenedioxy-6-propylbenzyl] [butyl]-diethylene glycol ether) (6-Propylpiperonyl butyl diethylene glycol ether)
Alpha Laboratories Inc.
Denver, Colorado
FMC Corporation
Chemical Group
Industrial Chemical Division
Baltimore, Maryland (Butoxide#)
McLaughlin Gormley King Company
Minneapolis, Minnesota
Millmaster Onyx Corporation
Millmaster Chemical Company, division
Berkeley Chemical Department
Berkeley Heights, New Jersey

Pipron# (See: 3-[2-Methylpiperidino] propyl-3,4-dichlorobenzoate)

Pival# (See: 2-Pivaloyl-1,3-indandione)

2-Pivaloyl-1,3-indandione (Pindone) (2-Pivalyl-1-3-indandione)
MacKenzie Chemical Works, Inc.
Central Islip, New York (Pival®)
MOTOMCO, Inc.
Clark, New Jersey

2-Pivaloyl-1,3-indandione, sodium salt
(2-Pivalyl-1,3-indandione, sodium salt)
MOTOMCO, Inc.
Clark, New Jersey (Pivalyn®)

Pivalyn® (See: 2-Pivaloyl-1,3-indandione, sodium salt)

Planavin® (See: 4-[Methylsulfonyl]-2,6-dinitro-N,N-dipropylaniline)

PMA (See: Phenylmercury acetate)

Polyacrylonitrile, hydrolyzed, sodium salt
American Cyanamid Company
Industrial Chemicals and Plastics Division
Linden, New Jersey
Organic Chemicals Division
Woodbridge, New Jersey

Polychlorodicyclopentadiene isomers
(Polychloro-tetrahydro-methanoindene isomers)
Northwest Industries, Inc.
Velsicol Chemical Corporation, subsidiary
Memphis, Tennessee (Bandane®)

Polyram (See: Dithiobisthiocarbonyliminoethylene bis dithiocarbamic acid, zinc salt)

Pomarsol Z (See: Dimethyldithiocarbamic acid, zinc salt)

Potassium cyanate (KOCN)
American Cyanamid Company
Lederle Division
Fine Chemicals Department
Linden, New Jersey (Cyanogum® 44)
Diamond Shamrock Corporation
Diamond Shamrock Chemical Company
Chemetals Division
Curtis Bay, Maryland

Pramitol® (See: 2-Methoxy-4,6-bis [isopropylamino]-1,3,5-triazine)

Prefar® (See: N-[β-O,O-Diisopropyldithiophosphorylethyl] benzene sulfonamide)

Preforan® (See: 2,4'-Dinitro-4-trifluoromethyl-diphenyl ether)

Princep® (See: Simazine)

Primaze (See: 2,4-Bis [isopropylamino]-6-methylthio-s-triazine)

Prolate (See: O,O-Dimethyl S-phthalimidomethyl phosphorodithioate)

Prometone (See: 2-Methoxy-4,6-bis [isopropylamino]-1,3,5-triazine)

Prometryne (See: 2,4-Bis [isopropylamino]-6-methylthio-s-triazine)

Propachlor (See: 2-Chloro-N-isopropylacetanilide)

Propanil (See: 3,4-Dichloropropionanilide)

Propazine (See: 2-Chloro-4,6-bis [isopropylamino] s-triazine)

2-Propenal (See: Acrolein)

2-Propen-1-ol (See: Allyl alcohol)

Propham (See: Isopropyl N-phenylcarbamate)

Prophos (See: O-Ethyl S,S-dipropyl phosphorodithioate)

Propoxur (See: o-Isopropoxyphenyl methylcarbamate)

n-Propyl-di-n-propylthiolcarbamate
(S-Propyl dipropylthiocarbamate) (Vernolate)
Stauffer Chemical Company
Agricultural Chemical Division
Cold Creek, Alabama (Vernam®)

n-Propyl ethyl-n-butylthiolcarbamate (PEBC)
(Pebulate) (S-Propyl n-butyl ethylthiocarbamate)
Stauffer Chemical Company
Agricultural Chemical Division
Cold Creek, Alabama (Tillam®)

n-Propyl isome (See: Di-n-propyl 6,7-methylenedioxy-3-methyl-1,2,3,4-tetrahydronaphthalene-1,2-dicarboxylate)

6-Propylpiperonyl butyl diethylene glycol ether (See: Piperonyl butoxide)

Protex (See: Rotenone)

Prussic acid (See: Hydrogen cyanide)

Pyramin® (See: 5-Amino-4-chloro-2-phenyl-3 [2H]-pyridazinone)

Pyrazon (See: 5-Amino-4-chloro-2-phenyl-3 [2H]-pyridazinone)

Pyrethrins (Pyrethrum)
CPC International, Inc.
S. B. Penick & Company, division
Montville, New Jersey
FMC Corporation
Chemical Group
Industrial Chemical Division
Baltimore, Maryland
McLaughlin Gormley King Company
Minneapolis, Minnesota (Pyrocide®)
Prentiss Drug & Chemical Co., Inc.
Newark, New Jersey

8-Quinolinol, copper salt (8-Hydroxyquinoline, copper salt) (Copper 8-quinolinolate) (Copper oxinate) (Copper oxyquinolate)
Ashland Oil, Inc.
Ashland Chemical Company, division
Chemical Products Division
Great Meadows, New Jersey (Milmer® 1)
Ferro Corporation
Ferro Chemical Division
Bedford, Ohio
Merck & Co., Inc.
Merck Chemical Division
Hawthorne, New Jersey
Tenneco Inc.
Tenneco Chemicals, Inc.
Intermediates Division
Elizabeth, New Jersey
Long Beach, California
Troy Chemical Corporation
Newark, New Jersey

Quinomethionate (See: 6-Methyl-2,3-quinoxalinedithiol cyclic S,S-dithiocarbamate)

Ramrod# (See: 2-Chloro-N-isopropylacetanilide)

Randox# (See: 2-Chloro-N,N-diallylacetamide)

Rhothane# (See: DDD)

Rogue# (See: 3',4'-Dichloropropionanilide)

Ro-neet# (See: S-Ethyl N-ethyl-N-cyclohexylthiocarbamate)

Ronnel (See: O,O-Dimethyl O-[2,4,5-trichlorophenyl] phosphorothioate)

Rotenone (1,2,12,12a-Tetrahydro-2-isopropenyl-8,9-dimethoxy [1] benzopyrano [3,4-b] furo [2,3-H] [1] benzopyran-6-[6aH]-one) (Protex)
Blue Spruce Company
Edison, New Jersey
Chemical Formulators, Inc.
Chemical Division
Nitro, West Virginia
CPC International, Inc.
S. B. Penick & Company, division
Lyndhurst, New Jersey
FMC Corporation
Chemical Group
Agricultural Chemical Division
Middleport, New York
North American Philips Corp.
PEPI, Inc., subsidiary
Thompson-Hayward Chemical Company, subsidiary
Leffingwell Chemical Company, subsidiary
Brea, California (Tox-R#)
Prentiss Drug & Chemical Co., Inc.
Newark, New Jersey

Ruelene# (See: O-[4-tert-Butyl-2-chlorophenyl]-O-methyl methylphosphoramidate)

Ryania
CPC International, Inc.
S. B. Penick & Company, division
Lyndhurst, New Jersey (Ryanicide#) (Prolin#)
North American Philips Corp.
PEPI, Inc., subsidiary
Thompson-Hayward Chemical Company, subsidiary
Leffingwell Chemical Company, subsidiary

Brea, California (Rynotox®)

SBP-1382 (See: [5-Benzyl-3-furyl] methyl-2,2-dimethyl-3-[2-methylpropenyl] cyclopropanecarboxylate)

SMDC (See: N-Methyldithiocarbamic acid, sodium salt)

Santophen® No.1 (See: o-Benzyl-p-chlorophenol)

Seedrin (See: Aldrin)

Sesone® (See: 2-[2,4-Dichlorophenoxy] ethanol sulfate, sodium salt)

Sevin® (See: 1-Naphthyl N-methylcarbamate)

Silica gel (See: Silica)

Silvex (See: 2-[2,4,5-Trichlorophenoxy] propionic acid)

Simazine (2,4-Bis [ethylamino]-6-chloro-s-triazine)
(2-Chloro-4,6-bis [ethylamino]-s-triazine)
Ciba-Geigy Corporation
Agricultural Division
McIntosh, Alabama (Princep®)

Sinbar (See: 3-tert-Butyl-5-chloro-6-methyluracil)

Sinox® General (See: 2-sec-Butyl-4,6-dinitrophenol, ammonium salt)

Sinox® PE (See: 2-sec-Butyl-4,6-dinitrophenol, triethanolamine salt)

Sirmate® (See: Dichlorobenzyl methylcarbamate)

Sodam (See: Dimethyldithiocarbamic acid, sodium salt)

Sodium acid methyl arsonate (See: Methanearsonic acid, monosodium salt)

Sodium arsenite (Arsenious acid, sodium salt)
Alco Standard Corporation
Miller Chemical and Fertilizer Corporation, subsidiary
Hanover, Pennsylvania
Blue Spruce Company
Edison, New Jersey
Chempar Chemical Co., Inc.

Portland, Oregon
Filo Color and Chemical Corporation
Newark, New Jersey
Los Angeles Chemical Company
South Gate, California
Mallinckrodt Chemical Works
Industrial Chemicals Division
St. Louis, Missouri
Pennwalt Corporation
Chemical Division
Tacoma, Washington
Somerset Tire Co.
Bound Brook, New Jersey
Standard Oil Company of California
Chevron Chemical Company, subsidiary
Ortho Division
Maryland Heights, Missouri
Richmond, California
Triangle Chemical Company
Macon, Georgia

Sodium chlorate

Sodium fluoride

Sodium fluoroacetate
Fike Chemicals, Inc.
Nitro, West Virginia
Tull Chemical Company, Inc.
Oxford, Alabama ("1080" Rodenticide)

Sodium o-phenylphenate (See: o-Phenylphenol)

Sodium tetraborate (See: Sodium borates)

Stabilene® (See: Butoxypolypropylene glycol)

Stam® (See: 3',4'-Dichloropropionanilide)

Strobane® (See: Chlorinated mixed terpenes)

Succinic acid, 2,2-dimethylhydrazide (See: N-Dimethylamino succinamic acid)

Sucker-Stuff® (See: Maleic hydrazide)

Sulfoxide (1,2-Methylenedioxy-4-[2-(octylsulfinyl) propyl-1] benzene) (n-Octyl sulfoxide of isosafrole) (1-Methyl-2-[3,4-methylenedioxyphenyl] ethyl octyl sulfoxide)

CPC International, Inc.
  S. B. Penick & Company, division
    Montville, New Jersey

Sulfur

Sutan® (See: S-Ethyl diisobutylthiocarbamate)

Systox® (See: O,O-Diethyl O [and S]-2-[ethylthio] ethyl phosphorothioates)

2,4,5-T® (See: [2,4,5-Trichlorophenoxy] acetic acid)

2,3,6-TBA (See: 2,3,6-Trichlorobenzoic acid)

TBTO (See: Bis [tri-n-butyltin]oxide)

TCA (See: Trichloroacetic acid)

2,4,5-TCPPA (See: 2-[2,4,5-Trichlorophenoxy] propionic acid)

TEPP (See: Ethylpyrophosphate)

TIBA (See: 2,3,5-Triiodobenzoic acid)

2,4,5-TP (See: 2-[2,4,5-Trichlorophenoxy] propionic acid)

Tabatrex® (See: Di-n-butyl succinate)

Tedion® (See: 4-Chlorophenyl-2,4,5-trichlorophenyl sulfone)

Telone (See: 1,3-Dichloropropene, 1,2-dichloropropane mixture)

Telvar® (See: 3-[p-Chlorophenyl]-1,1-dimethylurea)

Temik® (See: 2-Methyl-2-[methylthio] propionaldehyde O-[methylcarbamoyl] oxime)

Terbacil (See: 3-tert-Butyl-5-chloro-6-methyluracil)

Terpene polychlorinates (See: Chlorinated mixed terpenes)

Terpinyl thiocyanoacetate (See: Isobornyl thiocyanoacetate)

Terraclor® (See: Pentachloronitrobenzene)

Terrazole# (See: 5-Ethoxy-3-trichloromethyl-1,2,4-thiadiazole)

cis-N ([1,1,2,2-Tetrachloroethyl] thio)-4-cyclohexene-1,2-dicarboximide (N-Tetrachloroethylthio-1,2,3,6-tetrahydrophthalimide)
Standard Oil Company of California
Chevron Chemical Company, subsidiary
Ortho Division
Richmond, California (Difolatan#)

2,3,5,6-Tetrachloro-4-(methyl sulfonyl) pyridine
Dow Chemical U.S.A.
Pittsburg, California

2,3,4,6-Tetrachlorophenol
Dow Chemical U.S.A.
Midland, Michigan (Dowicide# 6)

Tetrachloroquinone (See: Chloranil)

O,O,O',O'-Tetraethyl S,S'-methylene bisphosphorodithioate (See: Ethion)

Tetraethylpyrophosphate (See: Ethylpyrophosphate)

Tetraethylthiuram disulfide (See: Bis [diethylthiocarbamoyl] disulfide)

Tetrahydro-3,5-dimethyl-2H,1,3,5-thiadiazine-2-thione (See: 3,5-Dimethyltetrahydro-2H,1,3,5-thiadiazine-2-thione)

1,2,12,12a-Tetrahydro-2-isopropenyl-8,9-dimethoxy [1] benzopyrano [3,4-b] furo [2,3-h] [1] benzopyran-6-[6aH]-one (See: Rotenone)

O,O,O',O'-Tetramethyl O,O'-thiodi-p-phenylene phosphorodithioate
American Cyanamid Company
Agricultural Division
Linden, New Jersey (Abate#)

Tetramethylthiuram disulfide (See: Bis [dimethylthiocarbamoyl] disulfide)

Tetramethylthiuram monosulfide (See: Bis [dimethylthiocarbamoyl] sulfide)

Tetra-n-propyldithionopyrophosphate

Stauffer Chemical Company
Agricultural Chemical Division
Mt. Pleasant, Tennessee (Aspon®)

Thallium sulfate
American Smelting and Refining Company
Denver, Colorado

Thanite® (See: Isobornyl thiocyanoacetate)

Thimet® (See: O,O-Diethyl S-[ethylthio] methyl phosphorodithioate)

Thiocyanic acid, 2-(2-butoxyethoxy) ethyl ester (See: 2-[2-Butoxyethoxy] ethyl thiocyanate)

Thiodemeton (See: O,O-Diethyl S-[2-(ethylthio) ethyl] phosphorodithioate)

2-Thio-3,5-dimethyl-1,3,5-tetrahydrothiadiazine (See: 3,5-Dimethyltetrahydro-2H,1,3,5-thiadiazine-2-thione)

Thiodiphenylamine (See: Phenothiazine)

Thionazin (See: O,O-Diethyl O-[2-pyrazinyl] phosphorothioate)

Thiophal (See: N-[Trichloromethylthio] phthalimide)

Thiophanate
W. A. Cleary Corporation
New Brunswick, New Jersey

Thiram (See: Bis [dimethylthiocarbamoyl] disulfide under Rubber Processing Chemicals)

Tiguvon® (See: O,O,-Dimethyl O-[4-(methylthio)-m-tolyl] phosphorothioate)

Tillam® (See: n-Propyl ethyl-n-butylthiolcarbamate)

Tok® (See: 2,4-Dichlorophenyl-4-nitrophenyl ether)

p-Tolyl diiodomethyl sulfone
Abbott Laboratories
Chemical Division
North Chicago, Illinois

Topane® (See: O-Phenylphenol)

Tordon# (See: 4-Amino-3,5,6-trichloropicolinic acid)

Toxaphene (Chlorinated camphene)
Hercules Incorporated
Synthetics Department
Brunswick, Georgia (Toxaphene#)
Sonford Chemical Company
Houston, Texas
Tenneco Inc.
Tenneco Chemicals, Inc.
Intermediates Division
Fords, New Jersey (Strobane T#)

Treflan# (See: #,#,#-Trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine)

Tributyl (2,4-dichlorobenzyl) phosphonium chloride (Phosfon#)
Mobil Oil Corporation
Mobil Chemical Company, division
Industrial Chemicals Division
Charleston, South Carolina

S,S,S-Tributyl phosphorotrithioate
Baychem Corporation
Chemagro Corporation, division
Kansas City, Missouri (DEF#)

Tributyl phosphorotrithioite
(S,S,S-Tributyl trithiophosphite)
Mobil Oil Corporation
Mobil Chemical Company, division
Industrial Chemicals Division
Mt. Pleasant, Tennessee

S,S,S-Tributyl trithiophosphite (See: Tributyl phosphorotrithioite)

Trichlorfon (See: O,O-Dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate)

Trichloroacetic acid (TCA)
Dow Chemical U.S.A.
Midland, Michigan

Trichloroacetic acid, sodium salt
Dow Chemical U.S.A.
Midland, Michigan

2,3,6-Trichlorobenzoic acid (2,3,6-TBA)
Rorer-Amchem
Amchem Products, Inc., division

Ambler, Pennsylvania
Fremont, California
St. Joseph, Missouri
Tenneco Inc.
Tenneco Chemicals, Inc.
Intermediates Division
Fords, New Jersey

2,3,6-Trichlorobenzoic acid, lithium salt
Tenneco Inc.
Tenneco Chemicals, Inc.
Intermediates Division
Fords, New Jersey

2,3,6-Trichlorobenzoic acid, potassium salt
Tenneco Inc.
Tenneco Chemicals, Inc.
Intermediates Division
Fords, New Jersey

1,1,1-Trichloro-2,2-bis (p-chlorophenyl) ethane
(See: DDT)

1,1,1-Trichloro-2,2-bis (p-methoxyphenyl) ethane
(Methoxychlor) (DMDT) (Methoxy DDT) (2,2-Bis [p-methoxyphenyl] 1,1,1-trichloroethane)
The Ansul Company
Chemical Division
Marinette, Wisconsin ("Moxie")
Chemical Formulators, Inc.
Chemical Division
Nitro, West Virginia
E. I. du Pont de Nemours & Company, Inc.
Industrial Chemicals Department
Linden, New Jersey (Marlate®)
Prentiss Drug & Chemical Co., Inc.
Newark, New Jersey

Trichlorofon (See: O,O-Dimethyl 2,2,2-trichloro-1-hydroxyethyl phosphonate)

Trichloromethanethiol (See: Perchloromethyl mercaptan)

(N-Trichloromethylmercapto)-4-cyclohexene-1,2-dicarboximide (See: Captan)

N-(Trichloromethylthio)-4-cyclohexene-1,2-dicarboximide (See: Captan)

N-(Trichloromethylthio) pnthalimide (Folpet)
(Thiophal)

Standard Oil Company of California
Chevron Chemical Company, subsidiary
Ortho Division
Perry, Ohio (Phaltan®)
Stauffer Chemical Company
Calhio Chemicals, Inc., subsidiary
Perry, Ohio

N-Trichloromethylthiotetrahydrophthalimide (See: Captan)

Trichloronitromethane (See: Chloropicrin)

2,4,5-Trichlorophenol
Dow Chemical U.S.A.
Midland, Michigan (Dowicide® 2)
North Eastern Pharmaceutical and Chemical Company, Incorporated
Stamford, Connecticut
Occidental Petroleum Corporation
Hooker Chemical Corporation, subsidiary
Electrochemical and Specialties Divisions
Niagara Falls, New York
Transvaal, Inc.
Jacksonville, Arkansas

2,4,5-Trichlorophenol, ethanolamine salt
GAF Corporation
Chemical Division
Linden, New Jersey

2,4,5-Trichlorophenol, sodium salt
Dow Chemical U.S.A.
Midland, Michigan (Dowicide® B)

2,4,6-Trichlorophenol
Dow Chemical U.S.A.
Midland, Michigan

(2,4,5-Trichlorophenoxy)acetic acid (2,4,5-T)
Dow Chemical U.S.A.
Midland, Michigan
Transvaal, Inc.
Jacksonville, Arkansas

(2,4,5-Trichlorophenoxy)acetic acid, butoxyethanol ester
Dow Chemical U.S.A.
Midland, Michigan

(2,4,5-Trichlorophenoxy)acetic acid, n-butoxyethyl ester
Rorer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania

Fremont, California
St. Joseph, Missouri

(2,4,5-Trichlorophenoxy)acetic acid, butoxypolypropyleneglycol ester
Dow Chemical U.S.A.
Midland, Michigan

(2,4,5-Trichlorophenoxy)acetic acid, n-butyl ester
Chempar Chemical Co., Inc.
Portland, Oregon
PBI-Gordon Corporation
Kansas City, Kansas
Transvaal, Inc.
Jacksonville, Arkansas

(2,4,5-Trichlorophenoxy)acetic acid, sec-butyl ester
Dow Chemical U.S.A.
Midland, Michigan

(2,4,5-Trichlorophenoxy)acetic acid, N,N-dimethyloleyl/linoleyl amine salt
Transvaal, Inc.
Jacksonville, Arkansas

(2,4,5-Trichlorophenoxy)acetic acid, 2-ethylhexyl ester
(See: [2,4,5-Trichlorophenoxy]acetic acid, iso-octyl ester)
acid, iso-octyl ester)

(2,4,5-Trichlorophenoxy)acetic acid, iso-octyl ester
(2,4,5-T, 2-ethylhexyl ester)
Dow Chemical U.S.A.
Midland, Michigan
North American Philips Corp.
PEPI, Inc., subsidiary
Thompson-Hayward Chemical Company, subsidiary
Kansas City, Kansas
PBI-Gordon Corporation
Kansas City, Kansas
Riverdale Chemical Company
Chicago Heights, Illinois
Borer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania
Fremont, California
St. Joseph, Missouri
Transvaal, Inc.
Jacksonville, Arkansas

(2,4,5-Trichlorophenoxy)acetic acid, triethylamine salt
(2,4,5-T amine)
Chempar Chemical Co., Inc.
Portland, Oregon

Dow Chemical U.S.A.
Midland, Michigan
Transvaal, Inc.
Jacksonville, Arkansas

2-(2,4,5-Trichlorophenoxy)propionic acid
(2,4,5-TCPPA) (2,4,5-TP) (Fenoprop) (Silvex)
Dow Chemical U.S.A.
Midland, Michigan
Millmaster Onyx Corporation
Millmaster Chemical Company, division
Berkeley Chemical Department
Berkeley Heights, New Jersey
Transvaal, Inc.
Jacksonville, Arkansas

(2,4,5-Trichlorophenoxy)propionic acid, n-butoxyethyl ester
Riverdale Chemical Company
Chicago Heights, Illinois

(2,4,5-Trichlorophenoxy)propionic acid,
2-ethylhexyl ester (See: [2,4,5-Trichlorophenoxy]
propionic acid, iso-octyl ester)

(2,4,5-Trichlorophenoxy)propionic acid, iso-octyl ester
([2,4,5-Trichlorophenoxy]propionic acid, 2-ethylhexyl ester)
North American Philips Corp.
PEPI, Inc., subsidiary
Thompson-Hayward Chemical Company, subsidiary
Kansas City, Kansas
Riverdale Chemical Company
Chicago Heights, Illinois

(2,4,5-Trichlorophenoxy)propionic acid, sodium salt
Millmaster Onyx Corporation
Millmaster Chemical Company, division
Berkeley Chemical Department
Berkeley Heights, New Jersey
Riverdale Chemical Company
Chicago Heights, Illinois

(2,3,6-Trichlorophenyl) acetic acid, sodium salt
Rorer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania (Fenac®)
Fremont, California
St. Joseph, Missouri

Tridex (See: Diethyl dithiobis [thionoformate])

α,α,α-Trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine (Trifluralin)

Eli Lilly and Company
Tippecanoe Laboratories
Lafayette, Indiana (Treflan®)

3-(m-Trifluoromethylphenyl)-1,1-dimethylurea (See: 1,1-Dimethyl-3-[α,α,α-trifluoro-m-tolyl] urea)

2,3,5-Triiodobenzoic acid (TIBA)
Mallinckrodt Chemical Works
Industrial Chemicals Division
Raleigh, North Carolina
Borer-Amchem
Amchem Products, Inc., division
Ambler, Pennsylvania

Tris (2-hydroxyethyl) (phenylmercuri) ammonium lactate
W. A. Cleary Corporation
New Brunswick, New Jersey

Trithion® (See: O,O-Diethyl-[p-chlorophenylthiomethyl] phosphorodithioate)

Trolene® (See: O,O-Dimethyl O-[2,4,5-trichlorophenyl] phosphorothioate)

Tropital® (See: Piperonal bis [2-(2'-n-butoxyethoxy) ethyl] acetal)

Tupersan® (See: 2-[2-Methylcyclohexyl]-3-phenylurea)

Urab® (See: 1,1-Dimethyl-3-phenylurea trichloroacetate)

Urox® (See: 3-[p-Chlorophenyl]-1,1-dimethylurea trichloroacetate)

V-10® (See: Bis-1,4-bromoacetoxy-2-butene)

V-C 13® (See: O-2,4-Dichlorophenyl O,O-diethyl phosphorothioate)

VPM (See: N-Methyldithiocarbamic acid, sodium salt)

Vancide® (See: Dimethyldithiocarbamic acid, ferric salt)

Vapam® (See: N-Methyldithiocarbamic acid, sodium salt)

Vapona® (See: 2,2-Dichlorovinyl dimethyl phosphate)

Vegadex® (See: 2-Chloroallyl diethyldithio-carbamate)

Venzar# (See: Lenacil)

Verbigen (See: 3-Amino-2,5-dichlorobenzoic acid)

Vernam# (See: n-Propyl-n-propylthiolcarbamate)

Vernolate (See: n-Propyl-di-n-propylthiolcarbamate)

Vidden D (See: 1,3-Dichloropropene, 1,2-dichloropropane mixture)

Warbex# (See: O,O-Dimethyl O-p-[dimethylsulfamoyl] phenyl phosphorothioate)

Warfarin (3-[#-Acetonylbenzyl]-4-hydroxycoumarin)
(3-#-Phenyl-#-acetylethyl-4-hydroxycoumarin)
(Coumafene)
  Blue Spruce Company
    Edison, New Jersey
  MOTOMCO, Inc.
    Clark, New Jersey
  Prentiss Drug & Chemical Co., Inc.
    Newark, New Jersey

Weed Chek (See: [2,4-Dichlorophenoxy] acetic acid, lithium salt)

Yomesan (See: 2',5-Dichloro-4'-nitrosalicylanilide, 2-aminoethanol salt)

Zinc dimethyldithiocarbamate-cyclohexylamine complex (20% mixture)
  Nor-Am Agricultural Products, Inc.
    Chicago, Illinois

Zinc phosphide
  Occidental Petroleum Corporation
    Hooker Chemical Corporation, subsidiary
      Electrochemical and Specialties Divisions
        Niagara Falls, New York

Zineb (See: Ethylene bis [dithiocarbamic acid], zinc salt)

Zinophos# (See: O,O-Diethyl O-[2-pyrazinyl] phosphorothioate)

Ziram (See: Dimethyldithiocarbamic acid, zinc salt under Rubber Processing Chemicals)

Zobar# (See: Polychlorobenzoic acid, dimethylamine salt)

APPENDIX D

MIDWEST RESEARCH INSTITUTE SUMMARY OF PESTICIDES NOT LISTED BY THE U.S. TARIFF COMMISSION

Table D-1. PESTICIDES NOT LISTED IN "PESTICIDES AND RELATED PRODUCTS" SECTION OF SYNTHETIC ORGANIC CHEMICALS
UNITED STATES PRODUCTION AND SALES
(ANNUAL)
BY UNITED STATES TARIFF COMMISSION

Organics

Fumigants

Acrolein
Carbon disulfide
Carbon tetrachloride
Chloropicrin
Dichlorobenzene
Ethylene dibromide
Ethylene oxide
Formaldehyde
Naphalene

Fungicides

Dithane M-45® and Manzate 200®[a]
Niacide®
Polyram®
Thiram
Ziram

Others

Biphenyl
Metadehyde
Orthophenyl phenol
Sodium fluoroacetate
Other disenfectants, bacteriostate, germicides and water purifiers

Inorganics

Heavy metals

Copper sulfate
Calcium arsenate
Lead arsenate
Sodium arsenite
Acid copper chromate
Ammonical copper arsenite[a]
Chromated copper arsenates[a] ("CCA" salts)
Chromated zinc chloride[a]
Fluoro chrom arsenate phenol[a]
Potassium hexafluoroarsenate[a]

Others

Aluminum phosphide
Ammonium sulfamate
Calcium cyanide[a]
Cryolite[a]
Phosphoric acid[a]
Phosphorus[a]
Sodium chlorate
Sodium chlorate-borate
Sulfur and lime sulfur

Fossil fuel derivatives

Coal tars[a]
Creosote[a]
Petroleum oils[a]

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[a] Not included in the SRI list of pesticides.

APPENDIX E

MIDWEST RESEARCH INSTITUTE ESTIMATED PESTICIDE PRODUCTION IN 1972

ESTIMATED PESTICIDE PRODUCTION IN 1972

PART A. INSECTICIDES AND RELATED PRODUCTS

	Tariff Commission Production Data	MRI Estimated Production
CYCLIC INSECTICIDES, NEMATOCIDES, RODENTICIDES, REPELLANTS, ATTRACTANTS, SYNERGISTS AND ADJUVANTS		
ORGANOPHOSPHORUS INSECTICIDES		
Abate®		*
Azinphosmethyl (Guthion®)		*
Carbophenothion		*
Chlopyrifos (Dursban®)		*
Ciodrin®		*
Coumaphos		*
Crufomate		*
Diazinon		10
Dioxathion		*
Dyfonate®		*
Fensulfothion		*
Fenthion		*
Leptophos		*
Methyl Parathion	51.08	51.08
Parathion		13
Prolate (Imidan®)		*
Ronnel		*
Unassigned Production	44.39	21.38
Subtotal	(95.46)	(95.46)
ALDRIN-TOXAPHENE GROUP		
Aldrin		14
Chlordane		20
Dieldrin		*
Endrin		*

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* Included in Unassigned Production.

	Tariff Comission Production Data	MRI Estimated Production
Heptachlor		7
Toxaphene		95
Unassigned Production	141.86	5.86
Subtotal	(141.86)	(141.86)
CARBAMATE INSECTICIDES		
o-sec-Butylphenyl-N-methylcarbamate		*
o-Chlorophenyl-N-methylcarbamate		*
Carbofuran (Furadan®)		6
Carbaryl (Sevin®)		53
Formetanate		*
o-Isopropylphenyl-N-methylcarbamate		*
Metalkamate		8
m-Tolyl-N-methylcarbamate		*
Subtotal		(67.5)
CHLORO-ORGANIC INSECTICIDES		
BHC and Lindane		*
Chlorobenzilate		*
Chloropropylate		*
DDD (TDE)		*
DDT		40
Dicofol (Kelthane®)		*
2,6-Dimethyl-3,5-dichloro-4-pyridinol		*
Endosulfan		*
Kepone		*
Methoxychlor		*
Mirex		*
Perthane®		*
Tetradifon		*
Subtotal		(59.4)

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* Included in Unassigned Production.

	Tariff Commission Production Data	MRI Estimated Production
ALL OTHER CYCLIC INSECTICIDES, ETC.		
INSECTICIDES, N.E.C.		
Bacillus thuringiensis		*
Binapacryl		*
2-(p-tert-Butylphenoxy)cyclohexyl-2-propynl sulfite		*
N-(Phenyl-2-nitropropyl) piperidine		*
NEMATOCIDES		
Dichlofenthion		*
Thionazin		*
RODENTICIDES		
Diphacinone		*
Pindone		*
Warfarin		*
INSECT ATTRACTANTS AND REPELLANTS		
Deet		*
2-(3,4-Dichlorophenyl)-2,2,4-oxadiazoline-4-methyl-3,5-dione		*
MGK-326®		*
Trimedlure		*
SYNERGISTS AND ADJUVANTS		
Heliotropin acetal		*
1,2-Methylenedioxy-4-[2-(octylsulfinyl)propyl]benzene		*
MGK-264®		*
Piperonyl butoxide		*

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* Included in Unassigned Production.

	Tariff Commission Production Data	MRI Estimated Production
UNASSIGNED PRODUCTION	132.15	25.15
Subtotal, other cyclic insecticides		132.15
TOTAL, CYCLIC INSECTICIDES AND RELATED PRODUCTS	369.47	369.47
ACYLIC INSECTICIDES, NEMATOCIDES, FUMIGANTS AND SOIL CONDITIONERS		
ORGANOPHOSPHORUS INSECTICIDES		
Aspon®		*
Demeton O		*
Dichlorvos (DDVP)		*
Dicrotophos		*
Dimethoate		*
Disulfoton		8
Ethion		*
Malathion		25
Mevinphos		*
Monitor®		*
Monocrotophos		6
Naled		*
Oxydemeton methyl (Meta Systox®)		*
Phorate (Thimet®)		8
TEPP		*
Unassigned Production	65.18	18.18
Subtotal	65.18	65.18
ALL OTHER ACYLIC INSECTICIDES, ETC.		
INSECTICIDES		
Lethane 384®		*
Methomyl		*

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* Included in Unassigned Production.

	Tariff Commission Production Data	MRI Estimated Production
ACYLIC INSECTICIDES, NEMATOCIDES, FUMIGANTS AND SOIL CONDITIONERS		
NEMATOCIDES		
Aldicarb		*
Prophos		*
SOIL FUMIGANTS		
Chloropicrin		5
DBCP	(sales:15.23)	15
Dichloropropene and mixtures with related products		20
Methyl bromide	24.63	24.63
Methyl isothiocyanate		*
SOIL CONDITIONERS		
Polyacrylonitrile, hydrolyzed, sodium salt		15
UNASSIGNED PRODUCTION	104.3	49.3
Subtotal	128.93	128.93
TOTAL, ACYLIC INSECTICIDES AND RELATED PRODUCTS	194.11	

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* Included in Unassigned Production.

PART 3. HERBICIDES AND RELATED PRODUCTS

	Tariff Commission Production Data	MRI Estimated Production
CYCLIC HERBICIDES AND PLANT HORMONES		
TRIAZINES		
Ametryne		*
Atrazine		95
Prometryne		*
Propazine		*
Simizine		8
Subtotal		(110.0)
PHENOXIES		
Bromoxynil		*
4-CPA		*
2,4-D, dimethylamine salt	22.67	22.67
2,4-D, acid, esters and other salts		30
2,4-DB		*
MCPA		*
Silvex		*
2,4,5-T and derivatives		7
4-Chloro-2-methylphenoxy butyric acid		* *
Subtotal		(67.67)
ANILIDES		
Alachlor		24
Butachlor		5
Propachlor		35
Propanil		7
Subtotal		(71.0)

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* Included in Unassigned Production.

	Tariff Commission Production Data	MRI Estimated Production
DINITRO PHENOLS AND ANILINES		
Benefin		*
Dinoseb		*
DNOC		*
Nitralin		*
Trifluralin		21
Subtotal		(30.0)
AMIDES, IMIDES AND HYDRAZIDES		
Diphenamid		*
Maleic Hydrazide	4.47	4.47
UREAS		
Chloroxuron		*
Diuron		8
Fluometuron		*
Linuron		*
Monuron		*
Monuron-TCA		*
Siduron		*
Subtotal		(18.0)
URACILS		
Bromacil		8
Terbacil		*
BENZOICS AND RELATED COMPOUNDS		
Chloramben and derivatives		20
DCPA		*
Dicamba		*
2,5-Dichloro-6-nitrobenzoic acid, Na salt		*
Endothall		*
Picloram		*
Subtotal		(29.5)

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* Included in Unassigned Production.

	Tariff Commission Production	MRI Estimated Production
CARBAMATES AND THIOCARBAMATES		
Chloropropham (CIPC)		*
Cycloate		*
Propham (IPC)		*
OTHER CYCLIC HERBICIDES		
Bandane®		*
Barban		*
Bensulide		*
Gibberellic acid		*
3-Indolebutyric acid		*
Molinate		*
1-Naphthaleneacetic		*
acid and derivatives		*
Naptalam		*
Nitrofen		*
Phosphon		*
UNASSIGNED PRODUCTION	344.79	77.09
TOTAL, CYCLIC HERBICIDES	371.73	371.73
ACYCLIC HERBICIDES AND PLANT HORMONES		
AMIDES		
CDAA (Randox®)		6
THIOCARBAMATES AND RELATED COMPOUNDS		
Butylate		6
CDEC		*
Diallate		*
EPTC		5
Pebulate		*
Triallate		*
Vernolate		*

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* Included in Unassigned Production.

	Tariff Commission Production	MRI Estimated Production
CHLOROALKYLACIDS		
Dalapon		*
TCA		11.3
PHOSPHORUS COMPOUNDS		
Ethephon		*
DEF®		5
Merphos		*
ORGANO ARSENICALS		
Cacodylic Acid and Salts		*
Methane Arsonic Acid Salts, Total	30.70	
DSMA		6
MSMA		24
Alkylammonium Salts		*
OTHER ACYCLIC HERBICIDES		
DMSA		*
EXD		*
UNASSIGNED PRODUCTION	48.88	16.28
TOTAL, ACYCLIC HERBICIDES	79.58	79.58

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* Included in Unassigned Production.

PART C. FUNGICIDES

	Tariff Commission Production Data	MRI Estimated Production
CYCLIC FUNGICIDES		
MERCURY FUNGICIDES		
PMA	.31	.31
Phenyl mercuric oleate	.28	.28
Other mercury compounds	.27	.27
COPPER FUNGICIDES		
Copper 8-Quinolinate	.04	.04
Copper Naphthenate	2.21	2.21
POLYCHLORO AROMATICS		
Chloroneb		*
Chlorothalonil (Daconil®)		*
PCNB		*
Pentachlorophenol and salts	49.70	49.70
2,3,4,6-Tetrachlorophenol		*
2,4,5-Trichlorophenol and salts		18
2,4,6-Trichlorophenol		*
Subtotal		(70.35)
CHLOROALKYL IMIDES		
Captan		17
Captafol		*
Folpet		*
OTHER CYCLIC FUNGICIDES		
Benomyl		*
Benzylbromoacetate		*
2,6-Bis(dimethylaminomethyl)-cyclohexanone		*

---

* Included in Unassigned Production.

	Tariff Commission Production Data	MRI Estimated Production
OTHER CYCLIC FUNGICIDES (Concluded)		
2'-Bromo-4'-hydroxyacetophenone		*
5-Chloro-2-benzothiazolethiol, laurylpyridinium salt		*
Cyanomethylthiobenzothiazole		*
Dinocap		*
Diphenylammonium propionate		*
DMTT		*
Dyrene®		*
Ethoxyquin		*
Hexahydro-1,3,5-triethyl-s-triazine		*
Hexahydro-1,3,5-tris(2-hydroxyethyl)-s-triazine		*
2-Mercaptobenzothiazole, salt		*
Piperalin		*
Terrazole®		*
UNASSIGNED PRODUCTION	45.36	22.35
TOTAL, CYCLIC FUNGICIDES	98.16	98.16
ACYCLIC FUNGICIDES		
DITHIOCARBAMIC ACID DERIVATIVES		
Dimethyldithiocarbamic acid, K salt		*
Dimethyldithiocarbamic acid, Mn salt		*
Ethylene bis(dithiocarbamic acid), diammonium salt		*
Ferbam		*
Maneb		15
Nabam		*
Metham (SMDC)		5
Zineb		8
Unassigned Production	40.44	12.44

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* Included in Unassigned Production.

	Tariff Commission Production Data	MRI Estimated Production
OTHER ACYCLIC FUNGICIDES		
Bis-1,4-bromoacetoxy-2-butene		*
N,N-Bis(phosphonomethyl)glycine		*
Cadmium succinate		*
Chloromethoxypropylmercuric acetate		*
Copper tallate		*
Dimethylthiocarbonyldisulfide		*
Disodium cyanodithioimidocarbamate		*
Dodine		*
2-Hydroxypropylmethanethiol sulfonate		*
Korax		*
PETD		*
Unassigned production	4.21	4.21
TOTAL, ACYCLIC FUNGICIDES	44.65	44.65

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* Included in Unassigned Production.